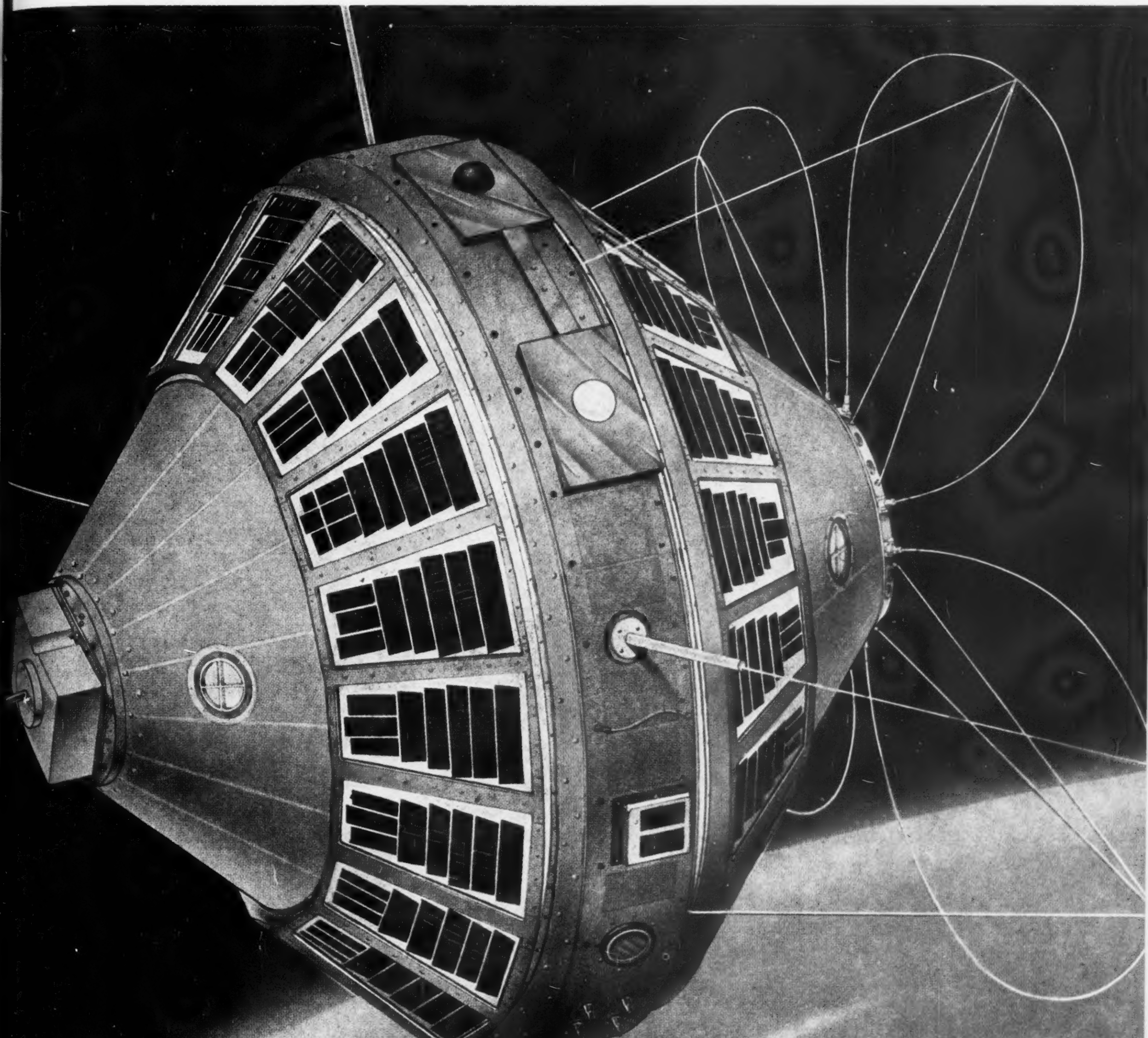
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

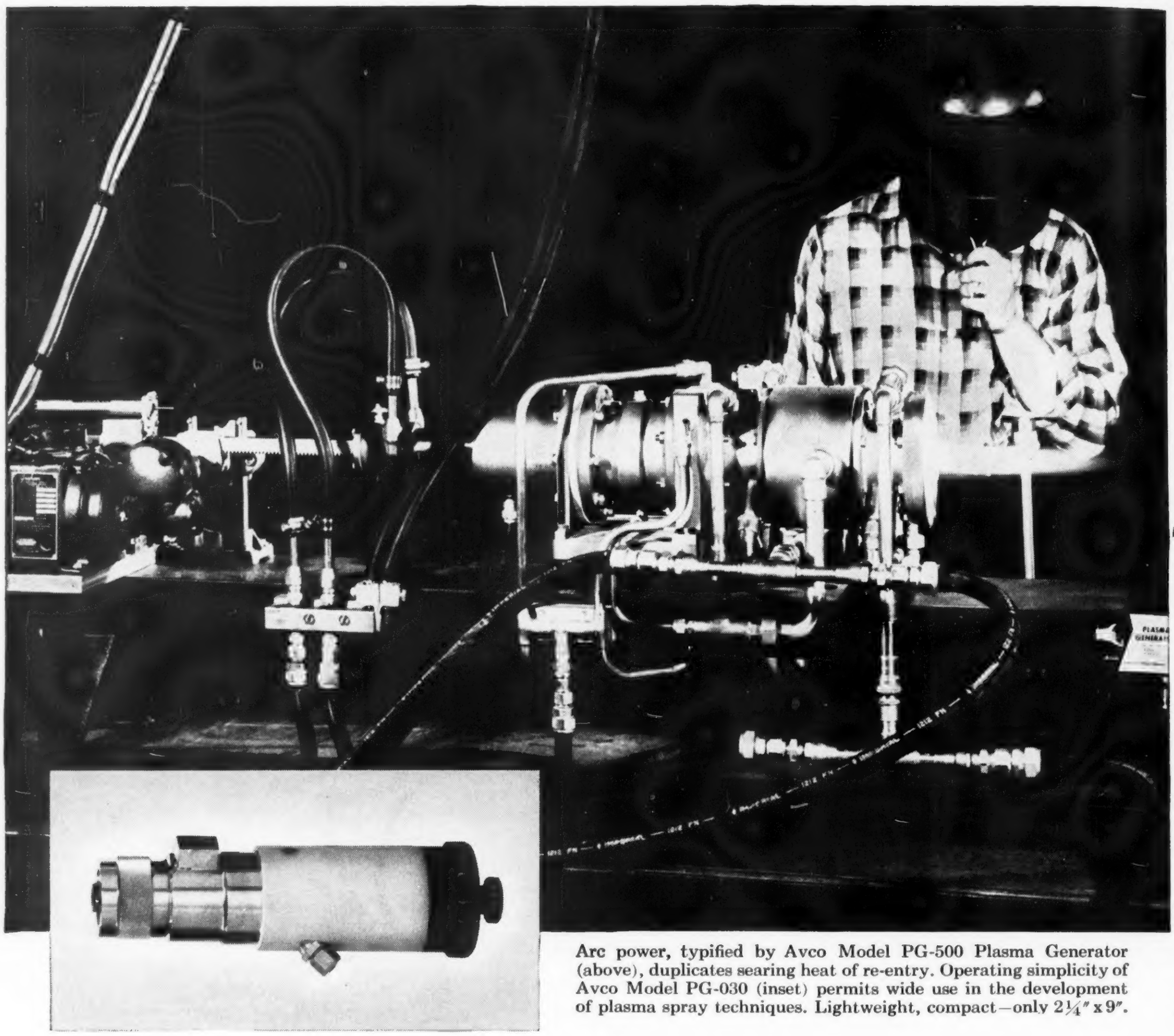
DECEMBER 1959



Mercury Capsule Communications . . . . Roger J. Pierce

Synthesis of Propellants in Manned Spaceships . . Eugene L. Colichman

Nature of Mars' Satellites



PLASMA GENERATOR

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC.

December 1959 volume 4 number 12

EDITORIAL

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DEPARTMENTS

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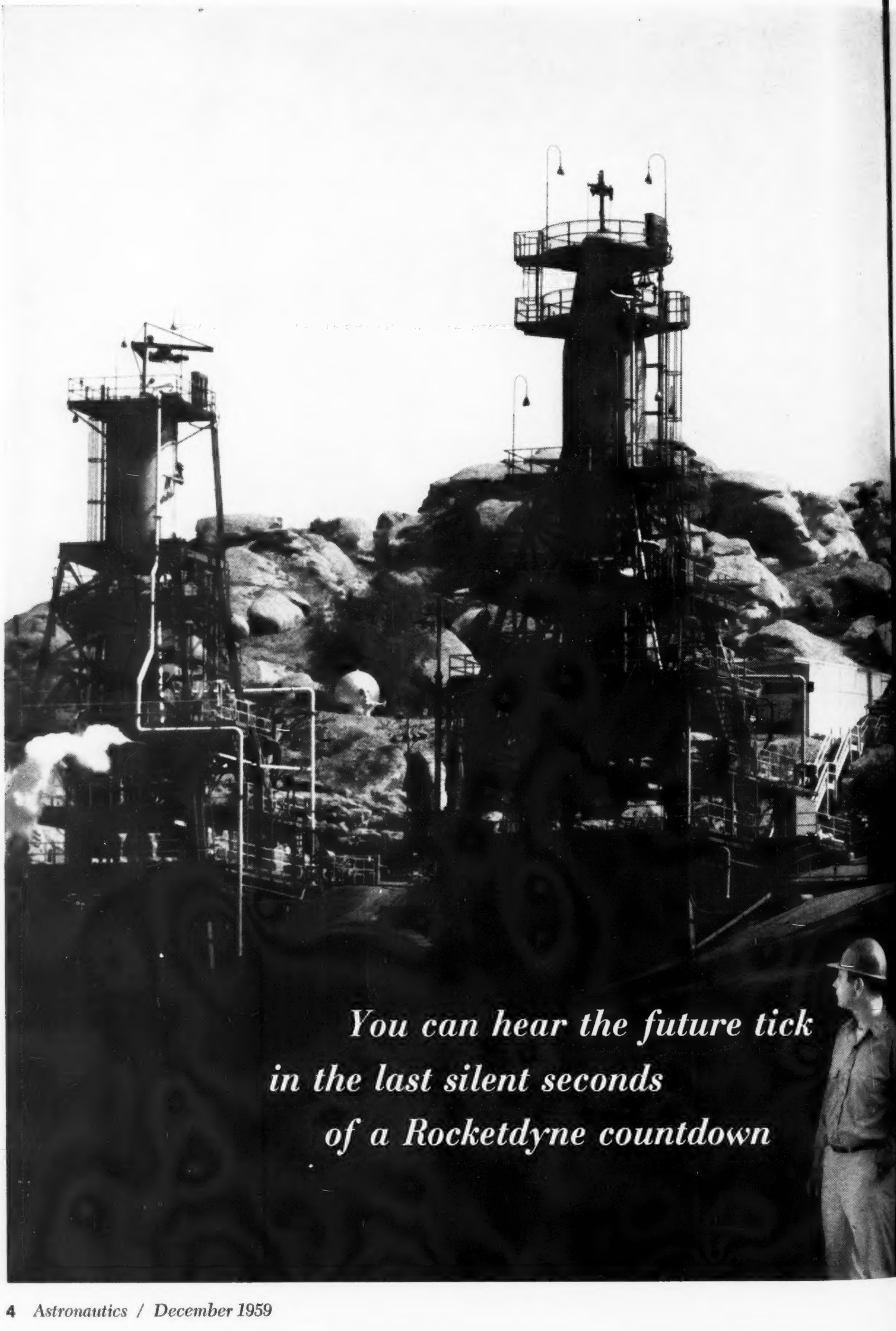

You can hear the future tick
in the last silent seconds
of a Rocketdyne countdown

Astro notes

MAN IN SPACE

• After a long delay, the Air Force named Boeing Airplane Co. and The Martin Co. prime contractors to develop the Dynasoar hypersonic rocket-boosted glider. Boeing will be responsible for the vehicle while Martin will provide the booster, presumably a Titan first stage. An elaborate Weapons System Project Office will be established at Wright Air Development Div. of ARDC to integrate the vehicle, booster, and subsystems and to supervise assembly and test. Boeing and Martin, the AF said, will select contractors for all major subsystems and components "on a competitive basis regardless of previous working relations during the developmental phase that preceded today's selection of contractors." (This was a reference to the separate "teams" assembled by Boeing and Martin during the design competition ordered a year ago.)

• As now envisaged, Dynasoar is strictly a research and development program, with no specific hardware applications so far determined. It will probably cost about $500 million and extend three to five years. The first Dynasoar will be an unmanned glider, weighing about 7000 lb, that will be extensively flight-tested in launchings from Cape Canaveral. Its successor will probably be a manned vehicle about 30 per cent larger. Both versions will have a maximum velocity of about 22,000 fps and both will employ a small turbojet engine for maneuvering during landing. The final version of Dynasoar contemplated by the program would have a weight of 15,000 to 20,000 lb and require a Saturn booster. This third model could lead directly to weapon-system applications, most likely suborbital bombing and reconnaissance.

• The AF decision to go ahead with Dynasoar was delayed because of budgetary considerations as well as uncertainty over how to manage the program. It is understood that Maj. Gen. Bernard Schriever wanted to establish the program along the same lines as the Ballistic Missile Div., with a contractor hired to provide technical monitoring. On the other hand, Lt. Gen. Samuel Anderson, commander of the Air Materiel Command, wanted the WSPO type of management organization, and his view prevailed.

• The Dynasoar decision makes it abundantly clear that the AF is determined to go ahead with its space ambitions, despite loss of the Saturn "superbooster" program to NASA and the fact that it will have to depend upon the civilian space agency for booster support in the later phases of Dynasoar.

• The latter agency, formerly lukewarm about Saturn, now sees it as a powerful tool for manned space operations, including such projects as a large space station. It has decided to turn over the Nova project to the Huntsville organization, but Saturn will get the emphasis. NASA will reportedly go along with the $140 million requested for Saturn for fiscal 1961, but whether it will expand this figure to the $250 million proposed by Wernher von Braun remains to be seen.

• While the federal government mobilized its resources to create the capability for manned spaceflight, a prominent Navy balloonist warned that extended manned spaceflight at the present time is "quite unrealistic." Malcolm D. Ross of the Office of Naval Research said high-altitude balloon research has shown that the sun emits torrents of energetic protons during periods of great solar activity which makes the hazards of the Van Allen radiation belts "seem pale by comparison." Measured dose rates at balloon altitudes have exceeded 10 roentgen per hour, while estimates for exposure rates above the atmosphere are about 1000 roentgen per hour. (Thirty minutes at this dose rate would be fatal to half the adults exposed.) Ross noted that the shielding required to protect men might be prohibitive in weight, and that it is still impossible to forecast solar activity.

SPACE PROBES

• Lunik III obtained a fine picture of the far side of the moon, giving the Russians first crack at naming a number of seas, craters, and mountain ranges (see page 28). Although the lighting was not ideal for astronomical studies (astronomers like plenty of shadow to throw the topography into relief), it was clear that the Russians had scored a solid new "first" in the space race with the West. Furthermore, Lunik III embodied systems as sophisticated as any planned by the U.S., including a command-receiver capability, stabilization and orientation, and a reliable high-resolution photographic and telemetry system.

• For its part, the U.S. was scheduled to take another crack at the moon late in November with a 375-lb payload propelled by an Atlas-Able. (The first attempt with this payload in early October was canceled when the Atlas burned down during a static-test.) With luck, the package may orbit the moon and even obtain some crude pictures. With an anticipated resolution of only 20 to 40 miles, however, it appears unlikely that the Atlas-Able observatory will uncover any prominent lunar features the Russians may have missed. (The 50-cm focal length camera in Lunik III had a resolution of about 3 miles.)

• NASA is scheduled to follow up the November moon shot with a payload of about 80 lb aimed in the vicinity of Venus. The planet itself will be on the other side of the sun when the package arrives, but the operation will provide a valuable test of NASA's interplanetary communications system.

• Meanwhile, expect no letup in the Russian spaceshots. A soft moon landing of instruments and a moon satellite are in preparation.

SATELLITES

• Discoverer VII failed in its attempt to return a 310-lb instrument capsule from orbit due to an electrical malfunction which prevented firing of the capsule's retrorocket. Satellite stabilization also failed sometime after it achieved a 95-min orbit with a perigee of 104 miles and an apogee of 550 miles. General Electric engineers were convinced they had licked the battery failures which defeated two Discoverer capsule re-entry attempts in August. They incorporated a new and larger battery in the Discoverer VII capsule capable of heating itself during its circuit around the nightside of the earth.

• Continued difficulties with the Discoverer program may lead to a

reconsideration of the plan for physical re-entry of films obtained in the Samos reconnaissance satellite program. After the latest attempt, an ARPA official commented glumly: "It's beginning to look like the capsule re-entry is beyond the state of the art. We'll be able to carry a lot more weight with the Atlas-Agena, but we'll still be short of tracking coverage. It's awfully discouraging." The alternative to physical recovery of Samos data is transmission of the information by television techniques. Military officials hope to develop both systems, on the ground that they are supplementary rather than duplicating.

• NASA's Explorer VI (Paddlewheel) satellite expired Oct. 6, exactly 60 days after it went into orbit. It failed to respond to ground commands to broadcast telemetry despite numerous attempts from tracking stations. Exact cause of the malfunction is unknown, but NASA will add a redundant command receiver to future Paddlewheel-type payloads to prevent a recurrence. Paddlewheel was intended to operate for at least a year.

• The timetable for NASA's Thor-Delta has been shoved back six months. The initial firing will come next spring with the 100-ft Project Echo sphere as a payload in a very high (1000 miles) circular orbit. Other shots will include a lunar soft-landing payload, Tiros meteorological satellites, an ionospheric sounder, a geodetic satellite with a flashing light, and several space probes.

• The Navy finally confirmed the existence of the Pilot project, designed to orbit small satellites by firing multistage rockets from supersonic aircraft at high altitude. Tests were conducted last year at NOTS, China Lake, Calif., the Navy said, but added that it is extremely doubtful that anything went into orbit. The project has been discontinued, despite Navy hopes to develop a tactical reconnaissance satellite for fleet intelligence.

• NASA officials report that both the Vanguard III and the Explorer VII scientific satellites are working "excellently." Vanguard's magnetometer has proved to be more sensitive than anticipated, with the result that a fine catalog can be produced for the earth's magnetic field. Explorer VII (see page 30) is not transmitting as well as expected on its 20-mc station.

SPACE TECHNOLOGY

• NASA successfully conducted its first flight-test of a 100-ft inflatable sphere (see photo on page 41) in a dramatic rocket shot from Wallops Island, Va. Launched just after twilight, the aluminized Mylar sphere inflated as planned and soared to a maximum altitude of 250 miles. Visible for up to 10 min for hundreds of miles along the East Coast, the brilliant object unleashed a torrent of calls to police, AF, and Civil Defense authorities, none of whom had been briefed in advance by NASA. The 100-ft sphere is scheduled for an orbital attempt aboard a Thor-Delta rocket next spring as Project Echo. It succeeds NASA's ill-fated Beacon project, which involved two unsuccessful attempts to orbit a 12-ft sphere.

• Project Echo figures in plans for an "Orbital Post Office," discussed by Sidney Metzger in the August 1959 *Astronautics,* page 38. President Eisenhower recently hinted that the Post Office Dept. was making progress in developing a facsimile printing system for such a postal delivery scheme. The facsimile printing method being studied by the Post Office Dept. does not require the opening of original letters, thus answering one possible objection to the system.

• The Atlas-Vega booster now under development for NASA will be the first fully-guided three-stage rocket system available for U.S. space projects. The Jet Propulsion Laboratory is supplying a 30-lb inertial guidance system for the 6000-lb-thrust storable third-stage booster of Vega (see page 40), which is based on the guidance unit developed by JPL for the Army's Sergeant ballistic missile. Vega capabilities include 5000 lb in a nominal earth orbit, lunar payloads of 500–1200 lb, 800 lb to Venus and 500 lb to Mars.

• The spiral antennas discussed by Maurice Chatelain in the July 1959 *Astronautics,* page 44, are showing up on several satellite vehicles, e.g., Transit.

• The AF has awarded Allison Div. of General Motors Corp. a contract to design, develop, and test a Sterling-cycle external combustion engine to provide auxiliary power in earth satellites, much as the 24-hr "stationary" one. With a capacity of 3 kw, the unit will be capable of untended operation for up to 2 yr, Allison said. It is working on the engine with Philips Gloeilampenfabricken of Endhoven, Holland, whose engineers have increased the efficiency of the novel engine to about 40 per cent.

• General Electric is developing a magnetohydrodynamic generator designed to produce bursts of electrical energy large enough for brief interplanetary television communications (see page 24). Utilizing a solid-propellant rocket to send a stream of ionized exhaust gas through a magnetic field, the technique is expected to have high efficiency and possible weight savings over conventional mechanical generators.

• A balloon flight, similar to the one that carried instruments designed by Marcel Stein of Univ. of Chicago to a record height of 154,000 ft last Sept., is proposed by ONR and NSF early next year to test for anti-matter in the upper atmosphere.

• A Republic Aviation project for NASA includes the analysis and computer programing of lunar and interplanetary trajectories for space probes. Effects considered in calculation include gravitational attractions of Earth, Sun, Moon, Jupiter, Mars, and Venus and, near Earth, aerodynamic friction and the planet's newly discovered asymmetry. Intermittent propulsion may be considered later.

• Painstaking study of magnetometer records obtained during the third Argus high-altitude nuclear explosion in Sept. 1958 has disclosed that the detonation produced a magnetic shell around the earth in addition to the shell of electrons. The brief, worldwide magnetic shell occurred above the ionosphere, at an altitude of 300 to 500 miles. It was produced by the powerful distortion of the earth's magnetic field which occurred when the nuclear device spewed forth enormous quantities of charged particles. The phenomenon may be of use in a groundbased network to detect nuclear explosions in the upper atmosphere.

• There is now speculation that Lunik III data will be revealing as to the nature of the ionized gases detected in some concentration near the moon by Lunik II, that is, make clear whether the gases are provincially associated with the moon or are related to the general gaseous structure of interplanetary space.

NASA

• Good news for the national space program can be expected from the recent conference of representatives of NASA headquarters, JPL, and the ABMA development group at Huntsville. Future operations with Juno II were discussed. Representing NASA headquarters were Homer Newell, assistant director of the Office of Space Sciences; Leslie Meredith and James Kupperian of that office; and John F. Clark, chief of Planetary Science Programs.

• About a month before this meeting, JPL's director William Pickering announced that a new JPL Space Science Div. would assist NASA in its program of space exploration by undertaking both theoretical and experimental studies in space science, including the planning, execution, and analysis of projects in cooperation with appropriate NASA groups. A. R. Hibbs is acting chief of the new division, which at first will have two sections. Henry Richter, who was present at the Huntsville meeting, heads its Space Instruments Section. Manfred Eirmer is acting head of the Research Analysis Section.

• The new year will open for NASA with a round of Senate and House space committee investigations into progress in the national space program. The sound and the fury that will surely attend these investigations will perhaps be more than compensated by adequate Congressional backing of NASA projects. Some public pressure will probably help the NASA administration, which has shown a conservative bent until recently, develop a major space vehicle program commensurate with its indisputably thorough and farseeing one in space science (see July 1959 *Astronautics*, page 36).

ARPA

• Charles L. Critchfield was appointed to succeed Roy Johnson as director of the Advanced Research Projects Agency. A mathematician and physicist, Dr. Critchfield comes from his post as director of research for Convair. He will serve without salary to avoid conflict of interest laws.

• With the recent shifting of its space projects back to the individual services, ARPA appears concerned now virtually wholly with advanced schemes for ballistic missile defense.

SPACE LAW

• Although still holding back from participation in international discussion of space law through the United Nations, and balking at U.S. proposals for international regulation of the radio spectrum (see Radio Astronomy below), the Soviet Union came boldly forward with a proposed resolution that the U.N. General Assembly call an international scientific conference for the purpose of exchanging information derived from space experiments. Conflict over the number of seats allocated to the Soviet bloc in the U.N. Committee on Peaceful Uses of Outer Space could prevent this conference as well as the progress of international discussion of space law. The Soviet stand on representation in the U.N. Committee appears to be unreasonable and to have inhibited the response of the West to the Russians' novel overture.

RADIO ASTRONOMY

• Responding to the last-minute pleas of a group of U.S. radio astronomers, the government has moved to secure international agreement on a number of interference-free windows through which the astronomers can survey the universe with their new large antennas. Not all of the astronomers' demands could be met (one requested frequency fell in the middle of TV Channel 5), but the government agreed to urge the International Telecommunications Union, meeting in Geneva, to set aside a total of 17 frequencies for the astronomers, seven for their exclusive use and 10 more to be shared with existing users.

• The radio astronomers are bedeviled by the growing sensitivity of their instruments, which are now capable of tuning in signals as faint as a hundredth of a trillionth of a trillionth of a watt per square meter of antenna. With the radio spectrum increasingly saturated by manmade noise and space becoming more cluttered with satellites to reflect signals back to the earth, the astronomers are having a hard time trying to sort out nature's radio broadcasts from those of mankind. One astronomer advanced this half jocular solution: Build radio telescopes on the far side of the moon to escape the radio din from the earth.

• The Federal Aviation Agency is alarmed at Navy plans to use its huge 600-ft Sugar Grove, W. Va., radio telescope as a radar device. It is asking the Navy to install an auxiliary radar with the telescope which will automatically shut it off if an aircraft comes within 50 miles of its beam. Used as a radar, Sugar Grove presumably will be able to gather intelligence data from the ionospheric-backscatter technique of Project Teepee, which showed a capability of detecting distant nuclear-rocket explosions and rocket launchings. Cost of Sugar Grove is now edging toward $100 million.

TRACKING

• Satellites passing near the Hawaiian Islands will be tracked by the Pacific Missile Range unit at Kauai, Hawaii, under an expanded Navy contract with the present operator of the facility, Chance Vought's Range Systems Div. The contract covers Vought tracking and recording of data telemetered from Explorer VII, and will likely provide background for the Navy's Transit satellite tracking operations. The Kauai unit was set up primarily to track and compile data for the fleet on flights of the Regulus I missile.

MISSILES

• The Navy-Goodyear Subroc program to develop a long-range ASW weapon for use by a submerged submarine is reportedly moving ahead on schedule. The initial weapon will be a nuclear depth charge with a range through the air of approximtaely 30 miles. Ultimately, a torpedo type of homing weapon is planned, but tests with the Mark 44 acoustic torpedo have shown that further work must be done to ease the weapon's entry into the water if a torpedo is to function properly.

• The AF decided to wind up its Thor program ahead of schedule as a result of the U.S. agreement to supply a squadron of Jupiter intermediate-range missiles to Turkey. The agreement brings to a total of seven the number of IRBM squadrons to be stationed in Europe, including four Thor squadrons with a limited operational capability in England and two Jupiter squadrons planned for Italy.

• The Navy is pushing for a green light to develop "Super Talos," an advanced version of its present long-range, ship-launched antiaircraft missile. Capable of intercepting Mach 3 aircraft and even Subroc-type weapons, the new bird would have a range of 200 miles and a 360-deg radar coverage. Other new missiles on the Navy's shopping list are a Super Tartar

and a new Polaris designated C-1, which would have a range of 2000 n. mi.

• The Budget Bureau is taking a hard look at the Navy's Corvus air-to-surface missile, which is designed to home on the radar transmissions of its target. The weapon appears to be caught in the endless countermeasures battle. With pulse-jump radars which can operate over wide bandwidths becoming available, doubters are wondering how the Corvus electronics package will be able to follow a transmitter over a broad frequency range.

• Mean Tricks Department: Weapon planners are pondering the consequences and capabilities of ballistic re-entry warheads placed in long-lifetime equatorial orbits. Equipped with retrorockets and orientation systems, they could presumably be called down on enemy targets within an hour after an attack. One diplomatic advantage: The warheads wouldn't pass over Russia or China or, for that matter, over this country. But Brazil, Columbia, Ecuador, Indonesia, and the new countries of Africa would be sure to protest.

• The AF launched the first of the advanced Model-B versions of Mace from Cape Canaveral, to which testing operations were recently moved from New Mexico. Flight-tests down the Atlantic Missile Range will allow broader testing of the missile's new inertial guidance system, which is being produced by A. C. Spark Plug Div. of GM. The AF also began construction of a hardened Mace site at Canaveral to continue the launching studies begun earlier in the year in New Mexico. Martin now trucks the missile from Baltimore to the Cape for tests.

• The omnidirectional Aeroscore-C scoring system for target drones, an electro-optical device developed by Aerojet-General Ordnance Div., has a miss-distance range of 5000 ft and can score missiles with high or low closing speeds and in sizes as small as .50-cal bullets, giving data on range and course angle. The Aeroscore system was demonstrated at this fall's weapons meet at Tyndall AFB, Fla.

• RCA and Chrysler have developed a self-contained, capsulated television station that, dropped from a ballistic missile, will take and transmit pictures of warhead impact and destructiveness to a combat field station. Flight-testing of the 33-in.-long, cone-shaped capsule began last month at the Air Proving Ground, Fla., with drops from aircraft.

• The Army recently tested two identical Jupiter guidance and control systems in one missile. First of its kind in this country, the test provided an unusually complete check of the accuracy and reliability of the system.

• Chrysler has a target rocket based on the Jupiter missile under development for proposed Nike-Zeus testing in the Pacific.

• With renewed interest in conventional weapons, the Symposium on Non-Nuclear Warheads for Guided Missiles held at Picatinny Arsenal drew wide attention. Papers from the Symposium will be available in classified form.

R&D

• The latest survey by NSF indicates that the aerospace industry accounts for \$2.544 of \$7.155 billion spent on research and development in industry—or more than a third of the total.

• Arnold Engineering and Development Center will hold a classified symposium on simulated altitude testing of rockets and missile components on Dec. 1–2, with attendance limited to persons with necessary clearance.

• NASA will henceforth conduct all but a small part of its flight-test operations at its Edwards Facility, the NASA Flight Research Center.

• Southwest Research Institute's progress in metal-coating capsules for propellant containment has been good, but a continuous method for production has yet to be developed.

• Arthur D. Little's far-ranging yet concisely presented and readable study for the Naval Research Advisory Committee, "Basic Research in the Navy, Vols. 1 & 2," released last month, proposed in conclusion an interesting mathematical model of the research process. The report is studied with meaty arguments for well apportioned and undisrupted research.

• A Stanford-Research Institute engineering study group headed by J. S. Armold, working on their finding that most friction on the slippers of track-riding rocket sleds comes from rust and scale on top of the rails, has tested rail coatings of aluminum, lead, zinc, tin babbitt, and calcium hydroxide (in the form of ordinary whitewash). Zinc proved the best metallic coating, but the hydroxide was promising. Molybdenum slippers show good wearing properties, but the metal in present forms is too brittle. SRI is working on a suitable alloy. Track coating and ductile moly-alloy slippers promise smooth supersonic track rides.

• Also, new SRI apparatus for measuring creep and stress relaxation of solid propellants holds promise of analyzing the aging process of solids better than current methods.

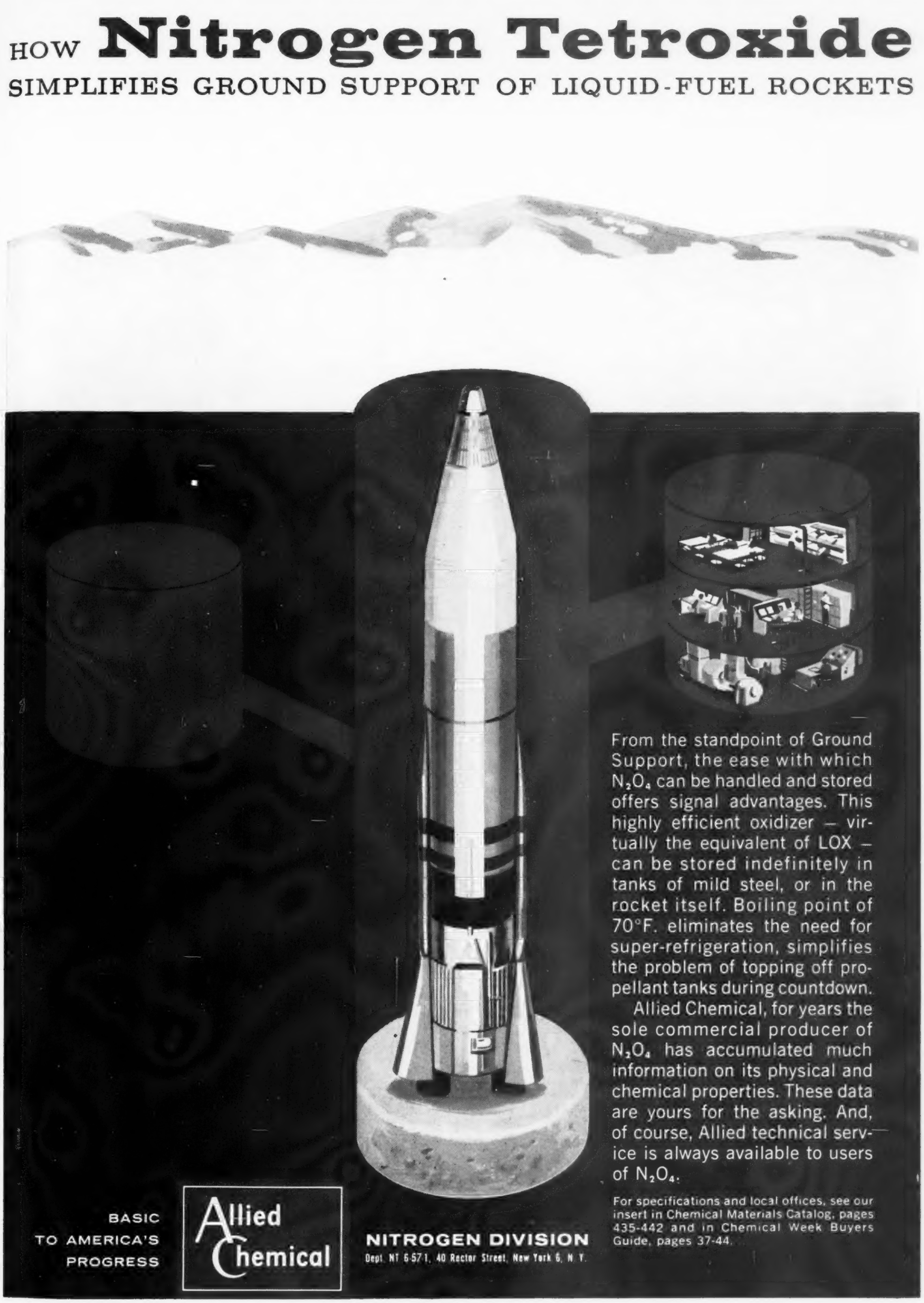
• A self-adaptive system for bringing about transition from reaction-jet to aerodynamic-surface controls will be studied by Minneapolis-Honeywell Regulator Co. under contract to WADC, in a program that may see an engineering prototype tested in the X-15.

• North American's Rocketdyne Div. has successfully fired a single-chamber rocket engine of 400,000 lb thrust. Designated the E-1, it is an outgrowth of the defunct Navaho program which required a rocket booster of that power. Work on the powerplant has continued at a low level, largely to explore the state of the art of large rocket motors. The outlook for the engine as a hardware item is dubious, however, because neither the AF nor NASA have booster projects requiring an engine of this size.

• Early in November, the X-15, with Scott Crossfield at the controls, suffered an explosion in the lower engine's No. 1 chamber during powered flight, necessitating dumping the propellant load and emergency landing, which broke the fuselage behind the cockpit. Crossfield was uninjured.

MATERIALS

• Beginning to show the high strengths predicted for them five years ago, aluminum alloys are taking an important place as motor-case material for large as well as small solid-propellant rockets. Alcoa expects new aluminum alloys to show a yield strength equivalent to 255,000 psi for steel in one-piece motor cases formed by a combination of forging and extrusion. Cases fabricated by Alcoa from wrapped alloy wire show strength-to-weight ratio over the million mark.


HOW Nitrogen Tetroxide
SIMPLIFIES GROUND SUPPORT OF LIQUID-FUEL ROCKETS
From the standpoint of Ground Support, the ease with which N_2O_4 can be handled and stored offers signal advantages. This highly efficient oxidizer – virtually the equivalent of LOX – can be stored indefinitely in tanks of mild steel, or in the rocket itself. Boiling point of 70°F. eliminates the need for super-refrigeration, simplifies the problem of topping off propellant tanks during countdown.
Allied Chemical, for years the sole commercial producer of N_2O_4 has accumulated much information on its physical and chemical properties. These data are yours for the asking. And, of course, Allied technical service is always available to users of N_2O_4.
For specifications and local offices, see our insert in Chemical Materials Catalog, pages 435-442 and in Chemical Week Buyers Guide, pages 37-44.
BASIC TO AMERICA'S PROGRESS
Allied Chemical
NITROGEN DIVISION
Dept. NT 6-57-1, 40 Rector Street, New York 6, N. Y.

2819

ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner

Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati 15, Ohio

NITROGEN TETROXIDE (N_2O_4)

Nitrogen tetroxide (N_2O_4) is a colorless gas which exists in equilibrium with the red-brown gas NO_2. At high temperatures the NO_2 predominates, but at room temperature and below the dimerized form is predominant. The liquid formed from the equilibrium mixture is faintly yellow.

Although nitrogen tetroxide has a very short liquid range under normal conditions, its high critical temperature allows it to be considered storable at high temperatures. The problem of a high freezing point remains, however, although some improvement is possible by mixing with other oxidizers, such as NO or NO_2F, at small performance losses. The tables shown give some of the properties of nitrogen tetroxide (molecular weight of 92.016).

Hazards

Nitrogen tetroxide reacts with water to form nitric and nitrous acids. These acids react with the alkali salts in the tissues of the respiratory tract, forming nitrates and nitrites. This causes intense irritation of the respiratory tract. High concentration of this gas can produce bronchial irritation at first, followed by dizziness, headaches, difficulty in breathing, and eventually death. This material has an insidious action, since it can attack without the patient being aware of it. Therefore, it is necessary that anyone who has inhaled a considerable amount of the gas be removed at once to a hospital for treatment. Personnel exposed to this material should use protective equipment. Recommended are chemical safety goggles for protection of the eyes and a respirator to avoid inhalation. Protective clothing is recommended to avoid skin contact. Maximum allowable concentration is 25 ppm by volume in air for exposure of not over 8 hr per day.

N_2O_4 is classified as a Class A poison and is required to bear a poison gas label.

Materials for Handling

Nitrogen tetroxide when dry (0.1 per cent moisture or less) is not corrosive to mild steel at ordinary temperatures and pressures. Numerous metals and alloys, such as carbon steel, stainless steel, aluminum, nickel, and Inconel are satisfactory for handling and storage. Under wet conditions, stainless steels resistant to about 60 per cent nitric acid serve best. Equipment parts, such as valve stems and blower shafts, partly in contact with the atmosphere should be stainless-steel construction of sufficient chromium content to resist corrosion caused by leaks through stuffing boxes. Good quality ceramic bodies and Pyrex are satisfactory for handling these oxides wet or dry. Of the plastic materials that withstand the oxides, Teflon and trifluorochloroethylene polymer films are most satisfactory.

Koroseal and Saran are useful, although somewhat limited in service life. In general, vinyl plastics do not hold up well in nitrogen tetroxide. Polyethylene is much more resistant chemically. Asbestos and asbestos-graphite are satisfactory for valve stuffing boxes. Koroseal has given reasonably good service in this use. For use on pipe threads, graphite-disodium silicate (water-glass) is recommended. Hydrocarbon lubricants should be avoided.

Cost and Availability

Production of N_2O_4 can be expanded very easily by any of the larger HNO_3 producers, and therefore supply is not considered a problem. Present cost is \$0.15/lb in 156-lb cylinders or 1-ton containers, \$0.075/lb in 15-ton lots, and \$0.065/lb in tank cars.

Table 1 Physical Properties of N_2O_4

Boiling Point	21.15 C	70.07 F
Freezing Point	−11.20 C	11.84 F
Critical Temperature	158.2 C	316.8 F
Critical Pressure	99.96 atm	1469 psia
Vapor Pressure		
at 70 F	...	14.78 psia
at 170 F	...	135 psia
at 250 F	...	544 psia
at 300 F	...	1160 psia
Liquid Density at 25 C (77 F)	1.431 g/cm^3	89.34 lb/ft^3
Viscosity		
at 70 F	0.41 centipoise	...
at 160 F	0.22 centipoise	...
at 250 F	0.09 centipoise	...
Thermal Conductivity		
at 40 F	...	0.081 Btu/hr ft F
at 100 F	...	0.072 Btu/hr ft F
at 160 F	...	0.056 Btu/hr ft F

Table 2 Chemical Properties of N_2O_4

Heat of Formation (liquid) at 25 C	−6.80 kcal/mole
Heat of Vaporization at Boiling Point	9.110 kcal/mole
Heat of Fusion at Freezing Point	3.502 kcal/mole
Heat Capacity at 17 C	33.71 cal/mole C
Maximum Allowable Concentration (in air for 8-hr day)	25 ppm

Table 3 Theoretical Performance of N_2O_4*

Fuel	Specific Impulse, sec — Frozen Flow	Specific Impulse, sec — Equilibrium Flow	Chamber Temperature** (Deg K)
N_2H_4	283	292	2994
UDMH ($C_2N_2H_8$)	274	285	3192
RP-1	263	276	3158

* P_c = 1000 psia; P_e = 1 atm; optimum O/F ratio.

** Corresponds to equilibrium flow impulse.

CUT ALONG THIS LINE

For the record

The month's news in review

Oct. 2—NASA announces it will ask Lockheed Aircraft to undertake basic nuclear-rocket research.

Oct. 4—Soviet Union launches Lunik III, expected to round and photograph far side of moon and then return and orbit earth.

—AF successfully fires Little Joe, carrying Mercury mockup, in operational test of launching and destruct systems.

Oct. 6—Soviet Union says Lunik III is rounding the moon, having passed within 4375 miles of it.

—AF fires Atlas 5500 miles, Thor 1700 miles.

—Soviet Union says it will ask for UN international conference "on the exchange of experience in exploring outer space."

—Radio transmission by Explorer VI ceases.

Oct. 8—Army demonstrates rocket-armed helicopter.

Oct. 10—Soviet Union discloses Lunik III is heading back to earth after reaching an apogee of 292,000 miles, and will orbit earth twice each month.

—House space committee report supports DOD cutbacks on high-energy fuel program.

Oct. 12—Navy Polaris fails due to second-stage malfunction.

Oct. 13—Army launches Explorer VII, a gyro-like satellite with $91^1/_2$-lb payload, into orbit around earth.

—AF B-47 successfully fires Bold Orion into vicinity of Explorer VI; anti-satellite missile lands in Atlantic 1000 miles from its aerial launching pad.

Oct. 14—Army achieves first successful test-flight of Nike-Zeus.

Oct. 15—U.S. announces plans to fire 10 instrumented rockets as its contribution to International Rocket Week Nov. 16–22.

Oct. 17—AF X-15 completes second successful powered flight.

—Roy W. Johnson, ARPA chief, resigns, but announces he will stay on until a successor is found.

Oct. 18—Soviet Union says Lunik III has succeeded in photographing far side of the moon.

—NASA schedules lunar shot for late November.

Oct. 19—Maj. Gen. John B. Medaris, AOMC commander, announces plans to retire Jan. 31.

Oct. 21—President Eisenhower transfers ABMA team, headed by Wernher von Braun, to NASA, subject to congressional approval.

Oct. 22—Navy shows prepackaged liquid propellant rocket engines operational for its Sparrow III and Bullpup missiles.

—Senate leader Lyndon B. Johnson orders Congressional inquiry into national space program.

—NASA announces it plans to keep ABMA at Redstone Arsenal.

—President Eisenhower says space program will require more than the $530,300,000 he requested of Congress for current fiscal year; announces that all Army missile projects except Saturn will be retained by AOMC.

Oct. 26—AF says its Discoverer VI ceased orbiting Oct. 20, on its 965th pass around earth.

—Smithsonian Astrophysical Laboratory reports Explorer IV "died" Oct. 22.

Oct. 27—Soviet Union releases Lunik III photos of far side of moon, which show topography to be "considerably more monotonous than that facing earth."

—Maj. Gen. August Schomburg is named to succeed Maj. Gen. John B. Medaris as head of AOMC.

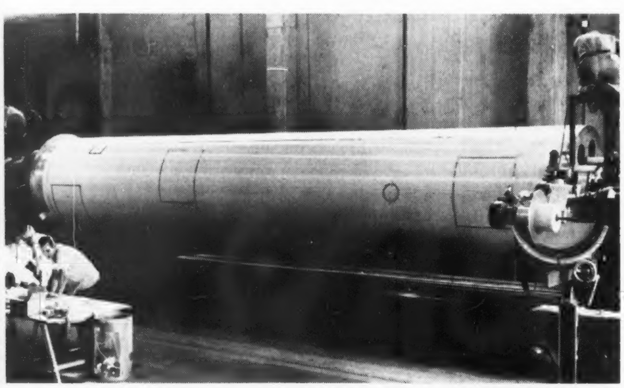
Oct. 28—A 100-ft-diam aluminum sphere inflates after successful ejection from Sergeant rocket in NASA test; civilian agency plans to use such "passive" balloon satellites for space communications.

—House space committee says it will begin national space program inquiry in January.

Oct. 29—AF test-fires advanced Mace-B.

—Roy W. Johnson, retiring ARPA chief, urges greater outlay for Saturn project.

Plastic Polaris Motor Case?



Shown during its production by Zenith Plastics Co., a 3M subsidiary, this wound reinforced-plastic cylinder measured 25 ft long and 57 in. in ID, but weighed less than 1000 lb. Its ovality and straightness compared well with metal construction of this size, according to Zenith. The company calls it a "missile" cylinder and made it for Lockheed Missiles and Space Div.

In print

Vistas in Astronautics, Vol. 2, edited by Morton Alperin and H. F. Gregory, Pergamon Press, New York, 1959, 318 pp., illustrated. $15.

The proceedings of the second AFOSR Astronautics Symposium, held in Denver last year, bring together some 20 technical papers; introductory remarks by Brig. Gen. H. F. Gregory and Morton Alperin of AFOSR, who edited the volume; a special report on Project Far Side; the brilliant banquet address by C. C. Furnas; and the interesting panel discussion on man in space which was one of the meeting highlights.

The technical papers are grouped into four categories, all of great interest to AFOSR. These are space environment and vacuum research; control and propulsion of vehicles outside the atmosphere; departure, navigation, and re-entry problems; and the moon.

Of particular interest is the lunar session, which produced a significant difference of opinion between astronomers Thomas Gold of Harvard and Fred Whipple of the Smithsonian Observatory on lunar dust; a brilliant dissertation on lunar exploration by Gerard Kuiper; and an interesting analysis of scientific and engineering exploration of the moon by John Barnes.

The space environment section is highlighted by a paper by Otto Schueller of the WADC Aero Medical Lab which proposed a number of designs for spaceflight simulators for animals and humans, as well as for zero-gravity and acceleration simulators; and a paper by Maurice Dubin of AF Cambridge Research Center on cosmic debris. The propulsion section includes papers on plasmajet propulsion, thrust production by electrostatic fields, propulsion utilizing a magnetic field as the driving force, and on instrumentation for a photographic reconnaissance of Mars. One of the more interesting papers in the space navigation section is that by J. H. Irving and E. K. Blum of STL comparing the performance of ballistic and low-thrust vehicles for flight to Mars.

The man-in-space session brought together such outstanding figures as A. F. Spilhaus, Homer J. Stewart, W. H. Pickering, George Gamow, and Dr. Whipple, and produced a good deal of interesting speculation as to the role man could and would play in space. It is unfortunate that Dr. Gamow's entertaining and humorous off-the-cuff remarks are not included; that only a small portion of the panel exchanges has been used; and that there is no mention of the fact that the panel discussion broke off after science-fiction writer Robert Heinlein had angrily denounced the panel from the floor for not being too enthusiastic about utilizing man in space.

A valuable extra in this handsome volume is the discussions and questions and answers after each paper.

—I.H.

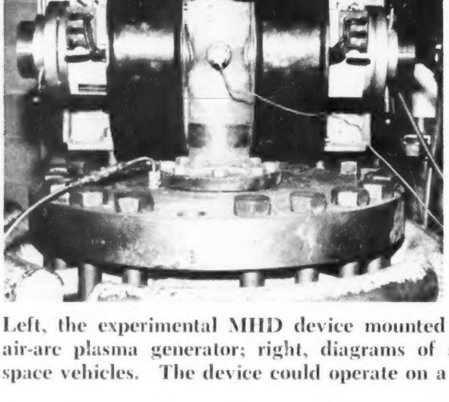
GE Tests MHD Power Generator

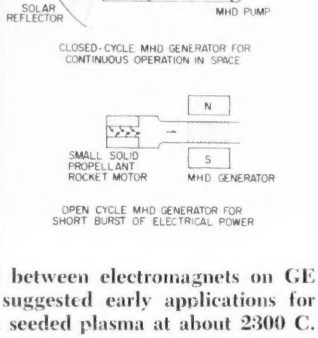
Scientists of GE's Missile and Space Vehicle Dept. have generated a kilowatt of electrical power for 5 sec with a laboratory MHD device operating off an air-arc plasma. Shown here mounted between two massive electromagnets on the plasma generator, the device consists simply of a ceramic duct tapped with electrodes. According to George W. Sutton, project engineer for MHD at GE's Aerosciences Lab, the device is not sensitive to its cross-sectional area, and may convert 40 to 50 per cent of thermal energy into useful electrical power.

The MHD generator suggests many possible applications—linked with a solid-propellant gas generator to supply high power for a short period, it could be used in transmitting TV pictures from a space probe; drawing plasma from a re-entry body to generate power; tapping a ramjet combustor, large chemical rocket engine exhaust, or working fluid of a nuclear rocket with a bypass for power generation; incorporated as an integral part of a plasma engine; etc.

Principal GE scientists concerned with the recent experiment, John McGinn and Willard Sutton, think a system working off a solid-propellant gas generator could be engineered in six months.

The big payoff of continuous power generation, they point out with Leo Steg, manager of the Aerosciences Lab who prompted the experiment, awaits the development of appropriate high-temperature materials and parasitic field-producing coils low in weight.





Left, the experimental MHD device mounted between electromagnets on GE air-arc plasma generator; right, diagrams of suggested early applications for space vehicles. The device could operate on a seeded plasma at about 2300 C.

BOOK NOTES

Long-term admirers of Arthur C. Clarke will be pleased to learn of publication of a revised (and largely rewritten) edition of his classic **Exploration of Space** (Harper, 200 pp., $4.50), originally published in 1952. Still one of the most sparkling and lucid explanations of rocketry and astronautics ever written, the book, which now faces spaceflight as a *fait accompli*, in contrast to its prophetic tone in 1952, belongs in every library.

If you've been searching for a book about astronautics for children, **Rockets into Space** (Random House, $1.95) is worth a look. Written by Alexander L. Crosby and Nancy Larrick and well illustrated, it describes rockets and how they work, satellites, space stations, and trips to the moon and Mars, in simple, lucid language, which should make easy reading for youngsters in the 8-to-11-age bracket.

C. W. Besserer of Space Technology Labs and F. E. Nixon of Martin-Orlando have been named editors of the new Prentice-Hall **Space Technology Series.**

Mail bag

Difference of Opinion

Dear Sirs:

I was disappointed to have seen your August 1959 edition include the article entitled "Science, Weapons, and Civilization" by Dr. Howard Wilcox. With all due respect to Dr. Wilcox's other apparent abilities, moral judgment does not appear to be one of them. I respect Dr. Wilcox's right to speak his opinions, but find it hard to understand why *Astronautics* sponsored such an article. The article clearly has no place in an ARS publication of this caliber. It adds nothing to the reader's knowledge of space technology. Perhaps the editors felt somewhat swayed by the author's title and position, but the statement included in his biography disclaiming any possible association with his views (and such a statement does not appear with any other article in the issue) leads me to believe that the decision to print the article was subject to some doubt.

Let me say in closing that the remainder of the August edition of *Astronautics* reflects the high standards that have made ARS publications the most read, most liked of their kind. Please don't succumb in the future to the temptation to publish on the basis of name rather than context. Your other issues have shown that many relatively unknown names have much to offer your readers.

PAUL C. HAMILTON
Associate Member, IAS
Wiesbaden, Germany

Ever since ASTRO *began publication, we have attempted to bring to the attention of our readers thought-provoking articles such as that by Dr. Wilcox. While it is true that article "adds nothing to the reader's knowledge of space technology," we have always felt that one of our functions is to set our readers to thinking about problems like those discussed by Dr. Wilcox. While we do not expect all of our readers to agree with the views held by the author, Mr. Hamilton's letter indicates that we have succeeded in this purpose.*

Incidentally, we were not the only ones to regard Dr. Wilcox's article as worthy of publication, since it has since been reprinted in the Space Digest *section of the* October 1959 Air Force*—Editor.*

Beg Pardon

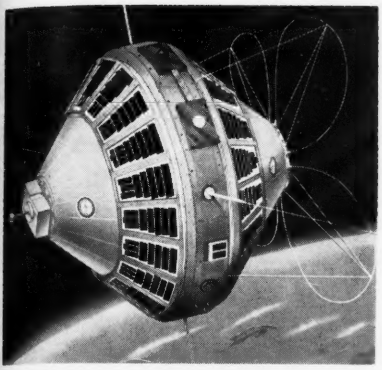
Dear Sir:

Referring to the "Astronautics Decimal Classification" published in the September issue of *Astronautics*, I beg to advise that the chairman of the Glossary and Documentation Committee (now "Classification and Standardization Committee) of the International Astronautical Federation is not Mr. H. H. Koelle, but myself. As a matter of fact, the classification system in question was distributed after the approval of the members of the committee in question and of myself.

GLAUCO PARTEL
Via Livorno 61
Rome, Italy

H. H. Koelle, who forwarded the classification system to us, has also written in to note that Mr. Partel headed up the committee which produced and approved the system.—Editor.


NUMBER EIGHT IN A SERIES... PRESSURE
PRECISION
FLOW
TEMPERATURE
ENDURANCE
SHOCK
ALTITUDE
HUMIDITY



COVER: *An artist's rendering shows Explorer VII, the latest in the series of satellites prepared and launched by ABMA and JPL for NASA, as it might appear in orbit, reaping data on earth's radiation balance (see page 30).*

Astronautics

DECEMBER 1959

Valedictory

By New Year's Eve, your 1959 president will have traveled almost one third of the distance to the moon on AMERICAN ROCKET SOCIETY business—37,850 miles to address 21 Section meetings and present 7 charters; 11,800 miles to attend 5 National Board and Executive Committee meetings; and 21,000 more miles to get to 2 national meetings, 4 specialist meetings, the International Astronautical Congress in London, and a visit with the Japanese Rocket Society in Tokyo. Total, 70,650 miles, including one hard landing by parachute near Denver.

From this jet-powered pilgrimage, an orbital view of the Society in action and personal contact with more than half the membership were obtained simultaneously. The projects begun by dedicated predecessors in office are attaining bounteous fulfillment throughout the activities of the 52 Sections and 22 Technical Committees.

The most exalting experience has been the close contact with conquest of space through association with leading contributors to its fulfillment. Regardless of national interests, their boundless scientific enthusiasm is hypergolic and universal. Hitherto earthbound human minds have been freed to vault to the borders of the universe with missiles, electronic communications, and computers. Bring on your infinity; the mind and imagination of man are no less!

In retrospect, the gain in membership has been more than matched by the AMERICAN ROCKET SOCIETY'S rise in authority and prestige among engineering societies in the international family of science. One individual who once regarded the ARS with scorn, expressed it most aptly as he remarked, "It's been a good year for the Rocket Society, hasn't it?" Your past president, happily soaking his feet in a hot basin, can think of nothing to improve on this summary.

In prospect, the AMERICAN ROCKET SOCIETY has just begun to grow and serve its mission as promoter and chronicler of Missile Engineering and Space Exploration. Under incoming President Seifert, progress will match the hurtling dynamics of the Space Age. As your past president, thank you for a wonderful experience.

John P. Stapp
PRESIDENT, AMERICAN ROCKET SOCIETY

Mercury capsule communications

A conservative approach, based largely on existing techniques and off-the-shelf designs, assures that the complex communications system for Project Mercury will be functional and reliable

By Roger J. Pierce
COLLINS RADIO COMPANY, CEDAR RAPIDS, IOWA

Roger J. Pierce is assistant to the director of engineering in the Cedar Rapids Div. of Collins Radio, assigned to special projects in space electronic systems. A 1932 graduate of Iowa State Univ. in electrical engineering, he first did graduate work at Ohio State Univ. in communications engineering, then joined Collins in 1934 as a communications engineer, and subsequently did various work in electronics at Harvard Univ., Motorola, Inc., and Hawaiian Telephone Co. Rejoining Collins in 1951, he has since been active in missile and space electronics systems, including those for Bomarc, Terrier, Triton, and Project Mercury.

COMMUNICATIONS in terms of human language and electrical language are vital for the success of NASA's Project Mercury manned spaceflight capsule. The journey of the manned capsule involves several phases of flight—prelaunch, launching, orbit, reentry, and recovery. The communications system must cover the requirements of all these phases both functionally and environmentally.

Collins Radio Company has undertaken to meet these requirements for NASA's prime contractor for the Mercury project, McDonnell Aircraft. Our discussion here describes the results of Collins' development work on the Mercury capsule communications. It covers the functional circuits necessary for the several phases of communication, the general problem of signal propagation, several special problem areas in manned-capsule electronics, each piece of major equipment developed to serve the functions of the capsule system, and expected design trends in future manned systems.

Outline of Mercury Communications Function

The illustration on the opposite page diagrams the Mercury communications functions as integrated into a complete system for the capsule and its ground counterpart. In a little more detail, these functions can be outlined as follows:

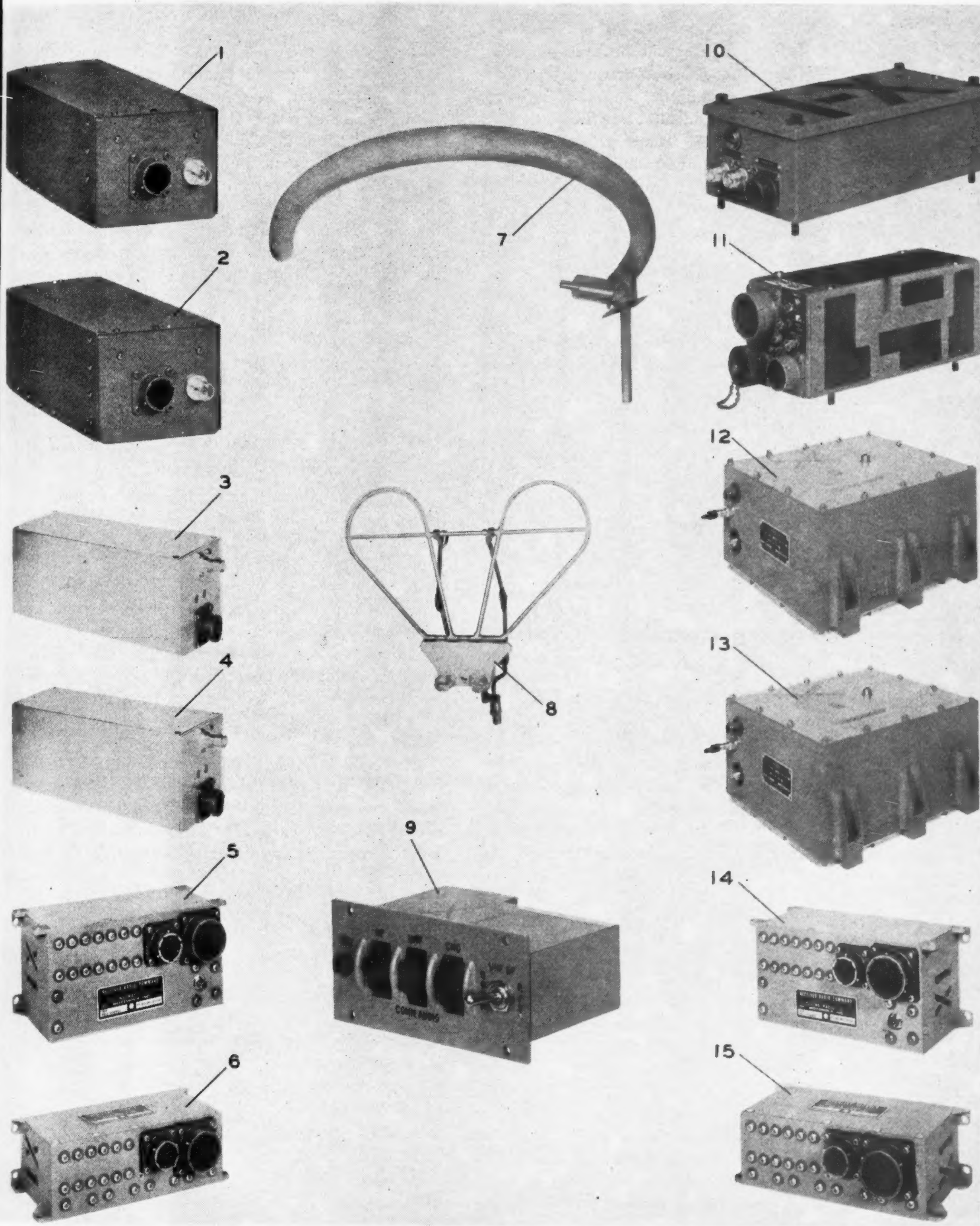
Voice Communication. It will be necessary for the Astronaut and the ground personnel to talk to each other during all phases of the mission. Redundant equipment will be used to give reliable voice communications in both orbital and rescue operations.

Command Function. Redundant command receivers with a substantial number of on-and-off channels will be provided to control various functions within the capsule during the launch, orbit, and re-entry.

Telemetry. Two telemetry transmitters will be provided to transmit scientific, operational, and aeromedical data from capsule to ground.

Orbital Tracking. A beacon operating on the "Minitrack" principle and capable of Microlock operation will be used for orbital tracking and a certain amount of telemetering.

Precision Tracking. Two radar transponder beacons in the microwave frequency range will be used for precision orbital tracking.



MERCURY CAPSULE EQUIPMENT

Project Mercury communications equipment: 1. HF voice transmitter-receiver; 2. HF rescue voice transmitter-receiver; 3. UHF voice transmitter-receiver (main); 4. UHF voice transmitter-receiver (backup); 5. command receiver "A"; 6. command decoder "A"; 7. bicone isolator; 8. UHF rescue antenna; 9. control unit; 10. HF/UHF rescue beacon; 11. audio center; 12. microwave beacon "A"; 13. microwave radar beacon "B"; 14. command receiver "B"; and 15. command decoder "B."

Rescue Beacons. Two rescue beacons, operating on the HF international distress frequency, will be provided for determining the capsule's bearings during retrieval operations at sea. One of these is a "Sea Save" CW beacon. The other will be in the UHF range and will use the pulsed "Sarah" principle. In addition, the UHF voice-communications transmitter permits use of "Locar" equipment for direction finding.

The system in the capsule must be compatible with the ground tracking and communications equipment at all locations planned for the worldwide network by NASA. This phase of the project has required considerable coordination by the designers of the equipment for the capsule and those responsible for the ground environment. Every effort has been made to insure adequate circuit margins over the distances contemplated for every function. System circuit margins were computed for distances of 700 n.mi. for the orbital phase and 200 n.mi. for the rescue phase.

Signal propagation in the frequency spectrum (HF to microwave) covered by the Mercury system was thoroughly investigated. There appear to be no propagation problems in the VHF, UHF, and microwave ranges. Experience with unmanned satellites provides some degree of certainty for VHF, UHF, and microwave circuit operation. Also, considerable thought has been given to HF propagation at satellite altitudes of approximately 100 miles, or just below the "F" layer. Theoretical investigations by propagation experts of Collins Radio and the NBS Propagation Laboratory in Boulder, Colo., indicate that HF at these altitudes should give good long-range multihop communications.

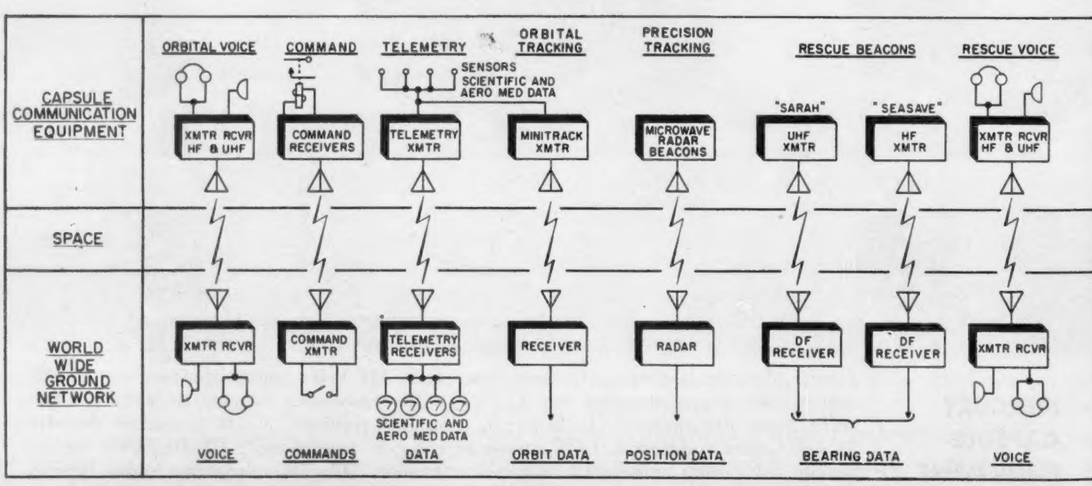
In contrast to UHF and microwave propagation, HF propagation is strongly influenced by the ionosphere. With a proper choice of frequency, the waves are reflected from the F layer, at a height of 250 to 400 km, and the transmission range becomes much greater than at VHF or UHF. A relatively high frequency is desirable to reduce absorption in the D region and to allow penetration of the E layer. On the other hand, the frequency must not be chosen too high, or waves may penetrate the F layer on the earth's nightside. A proper compromise will insure low absorption and long range under suitable conditions, and will avoid long periods during which reflection at the F layer fails. As long as a satellite remains below the region of maximum F-layer ionization, an HF channel can greatly improve the continuity and range of communication with the earth's surface.

Line-of-Sight Communications

Long-range communication becomes increasingly important when a satellite goes beyond line-of-sight. At present, Project Mercury line-of-sight communications will be limited to about 60 per cent of the total orbital period for the first three passes. After three passes the capsule will be beyond the line-of-sight range from the ground stations now contemplated for a considerable period of time. The use of high frequency should prove essential for these occasions. HF will also be of great value if the capsule is forced to descend in areas out of line-of-sight.

Although the design of electronic and electrical equipment for a manned space vehicle is somewhat similar to design for missiles, there are some notable differences. Let us look at a few areas that must receive special consideration—reliability, capsule

The Project Mercury Communications System



environment, size and weight, power demand, and environmental performance.

In the design of electronic equipment for the Mercury capsule, reliability is a factor of paramount importance along with functional adequacy. Missile reliability has been emphasized in the past few years, and considerable progress has been made in achieving a high degree of reliability for missile equipment. However, for a manned vehicle the reliability effort must be jumped to a still higher level. Failure of an electronic system may cause loss of a missile. Failure of communication electronics in a manned capsule obviously endangers the pilot and his ability to fulfill his mission.

With this in mind, Collins embarked on a thorough, comprehensive reliability program for Project Mercury. In this effort, the company's engineers teamed with consultants of Aeronautical Radio, Inc., to develop a reliability program and a reliability discipline for the Collins effort, as well as its subcontractors' efforts, in this program.

The reliability program designed to fulfill this requirement includes four basic areas of effort—design review, equipment and parts testing, fabrication and assembly surveillance, and failure-recurrence controls. As a part of the quality-assurance measures, all component parts are subjected to 100 per cent screening tests. Certain categories of parts, including semiconductors, are tested at elevated temperatures.

As a part of the reliability program, every consideration has been given to equipment redundance. Nearly every major function package in the communications system is duplicated, and multiple use of equipment provides alternate paths. For example, one of the telemetry transmitters may be keyed in an emergency to provide outgoing CW telegraph signals; some telemetering goes over the Minitrack beacon; and the UHF voice-communications transmitter doubles as a "locar" beacon.

Design Problems Confronted

The nature of the capsule environment presented design problems. The capsule will contain an atmosphere of pure oxygen. Special care must be taken in the design of electronic equipment that will operate in such an atmosphere. Consideration must also be given to the toxicity of any material used in the electronic equipment that would liberate toxic or irritating gases which the Astronaut might breathe. These problems have necessitated a complete review of all the materials of construction operating in an oxygen environment and the investigation of all materials to insure they do not liberate toxic gases in quantity sufficient to harm the Astronaut. For instance, it has been necessary to seal

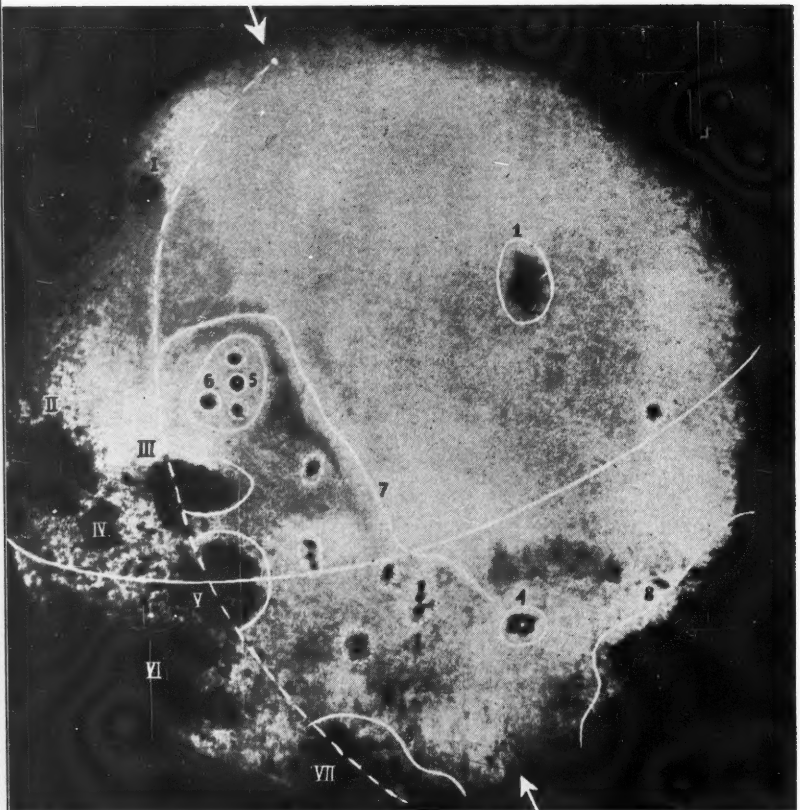
Antenna-Testing Mockup

all relay and switch contacts that produce heavy sparking. The sparking of these contacts liberates ozone, which, in sufficient quantities, can be toxic. Also, sparking might detonate contaminated oxygen.

A review of materials for the communications system indicates that the most serious offenders in producing toxins are fluorocarbon insulating compounds. Every effort is being made to eliminate such materials from equipment. Collins, McDonnell, NASA, and independent laboratories have studied the quantities of fluorocarbon material which the Astronaut could tolerate should there be a short circuit or fire within any component box.

As to size, components must be small and light. Much of the equipment designed by Collins and its subcontractors is foam-encapsulated. This permits mounting components on lightweight structures, such as printed boards and aluminum webs, to give very lightweight, rigid electronics packaging. Foam encapsulation compromises, but does not prevent, easy repair of these packages. Isocyanate foams in use are soluble in acetone and may also be chipped or blown out to expose a defective part.

Power Demand. The total power demand of the communications system must be kept quite low. Transistors and semiconductor devices have thus been used wherever pos- (CONTINUED ON PAGE 86)



First photo of far side of moon. Lines and numerals have been added for clarity. Solid line across diagram represents the moon's equator; dotted line is seen and unseen part of moon from earth. Solid lines around objects designate positively established objects; dotted lines, those objects which still need to be defined. Fine dots around objects are now being classified. Arrows indicate north pole (top), south pole (bottom).

Arabic numerals indicate following: 1. Moscow Sea, a crater 187 miles in diam; 2. Astronauts Bay; 3. continuation of south sea on moon's face; 4. crater of the main Tsiolkovskii Hill; 5. crater of the central Lomonosov Hill; 6. Joliot-Curie crater; 7. Sovietsky mountain range; 8. Dream Sea.

Roman numerals are portions visible from earth: I. Humboldt's Sea; II. Sea of Crises; III. Marginal Sea; IV. Sea of Waves; V. Smyth's Sea; VI. Sea of Fertility; VII. Southern Sea.

Russia's Project Far Side

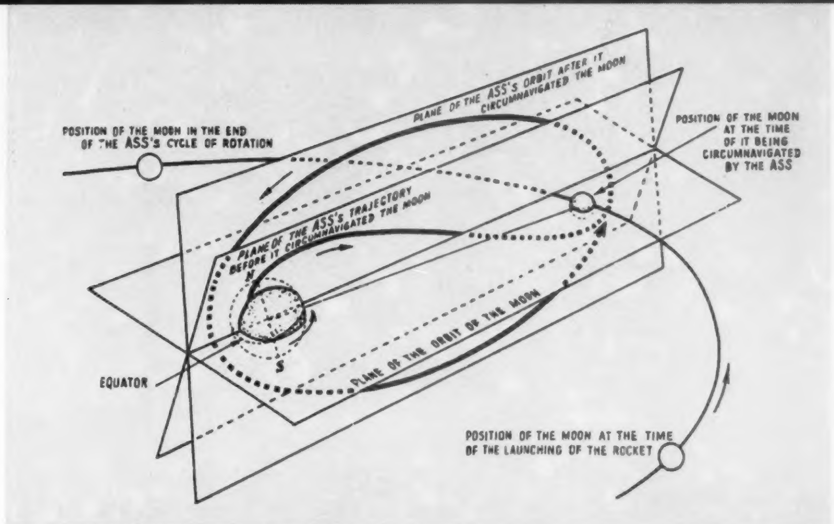
Lunik III photos show topography of hidden side of moon is "considerably more monotonous" than the side which faces the earth

THE SOVIET UNION celebrated the second anniversary of Sputnik I by launching a 631-lb space vehicle, Lunik III, on a 600,000-mile elliptical trajectory around the far side of the moon and then back to orbit around the earth. While it rounded the moon, equipment aboard the vehicle snapped man's first pictures of the hidden side of the moon and transmitted them to Soviet ground stations.

Preliminary analyses of the photos (one shown above) by Soviet and American scientists revealed a difference between the far side and the side of the moon facing earth. The data show that the back side has fewer and smaller maria, or seas, and is largely covered by mountains. The largest depression noted stretches 187 miles across; it has been named the Moscow Sea. As explained by Prof. Aleksandr A. Mikhailov, director of Pulkovo Observatory, the topography is "considerably more monotonous," which was "beyond doubt associated with the question of the origin of the configuration of the moon."

To achieve this photographic feat, the vehicle, at about 37,000 to 43,000 miles from the moon, was brought into position via automatic ground controls so that the lens pointed at the moon. Then the camera shot a 40-min series of exposures in bright sunlight, capturing 70 per cent of the far side of the moon on film. The photos, already developed in the vehicle, were transmitted by a special radio transmission system as the vehicle approached its perigee, some time on Oct. 18.

The closest the vehicle came to the moon was calculated as 4375 miles. Its speed when it reached its apogee of 292,000 miles was only 868 mph. The Soviets predict that the vehicle, ejected from a multistage rocket, will last about six months, and will

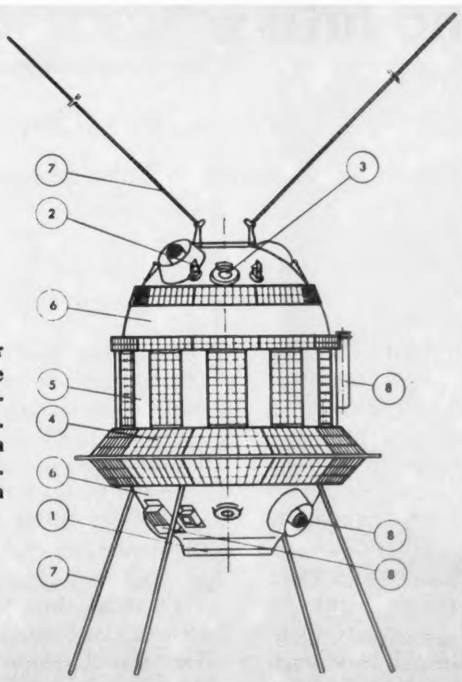


Trajectory of Lunik III

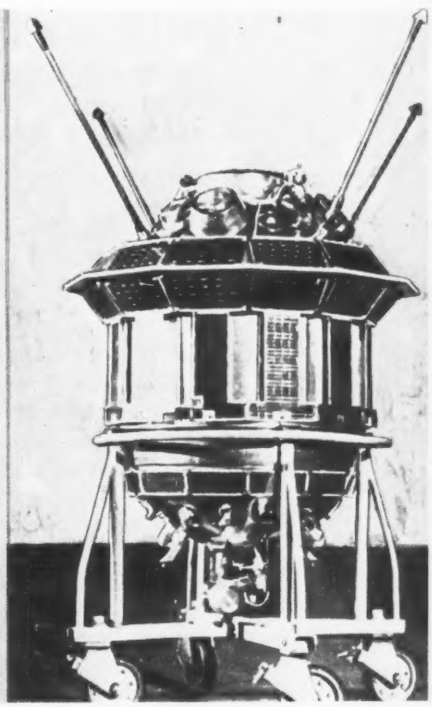
make about 11 to 12 sweeps around earth, each orbit taking about 15 days.

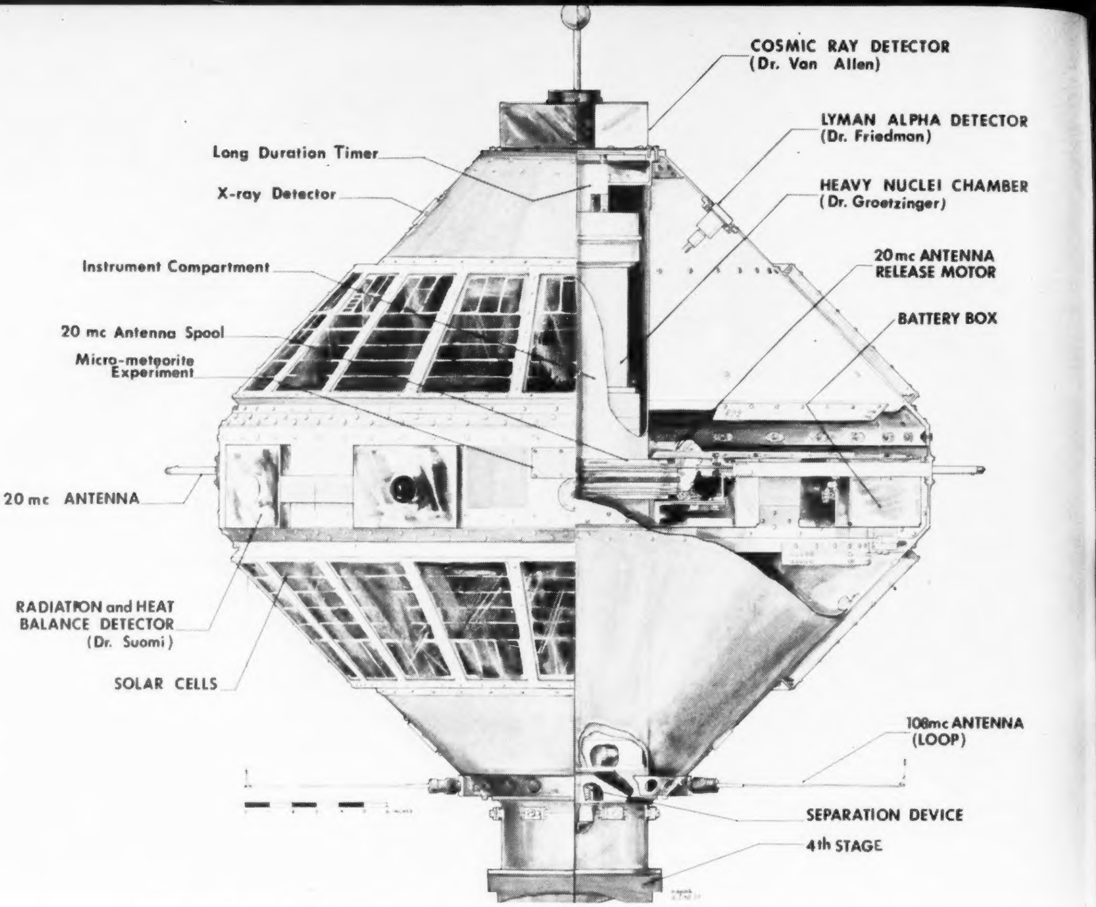
Soviet scientists hope that the data received will provide clues as to how the moon was formed; the physical properties of the atmosphere surrounding the earth and the moon; information "on such questions as determining the position of the moon's center of gravity and the degree of density of the earth; and may facilitate the study of the uneven revolution of the earth on its axis and the consequent variation in the length of days."

American scientists expressed excitement over the picture and made no bones about the useful information that might be obtained from the photographs. The apparent differences between the two sides of the moon have whetted their curiosity even more. One explanation forthcoming from Gerard P. Kuiper of the Univ. of Chicago's Yerkes Observatory was that evidently the moon's face "got banged up a lot more than" its far side. This was in reference to speculation by Dean B. McLaughlin of the University of Chicago that meteoritic showers blitzed one side of the moon in less time than it took the natural satellite to turn. ◆◆



Lunik III Payload: 1. Illuminator for cameras; 2. motor of the orientation system; 3. solar monitor; 4. sun battery section; 5. shutters of the thermoregulation system; 6. thermo screens; 7. aerials; 8. unnamed research equipment.





Engineering sketch of Explorer VII, showing the positioning of components.

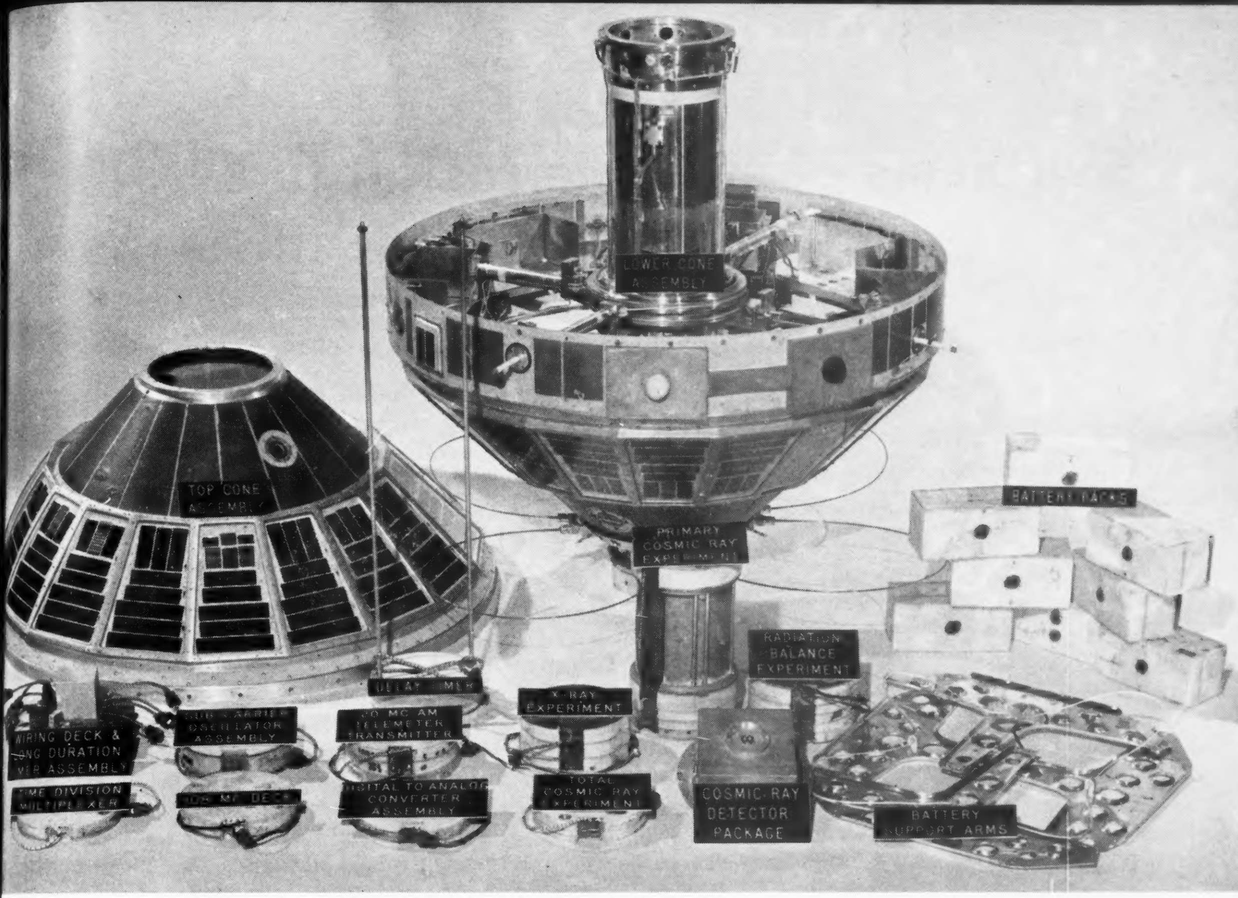
Ringing in the future

A campanile among satellites to date, Explorer VII heralds a new era in synoptic meteorology with its earth radiation balance experiments

By John A. Newbauer

ONCE AGAIN, on Oct. 13, an ABMA-JPL joint effort for NASA produced one of the finest space shots to date, the launching of Explorer VII, a 91.5-lb satellite incorporating seven major experiments on space radiations and satellite environment. Planned last March, the new satellite was itself designed, built, and launched by NASA's newly acquired space team from ABMA. As in several previous important launchings, such as Pioneer IV, a Juno vehicle supplied power for the shot. JPL engineered the three integrated high-velocity solid-propellant upper stages of Juno II. The first stage consists of a modified Jupiter missile booster.

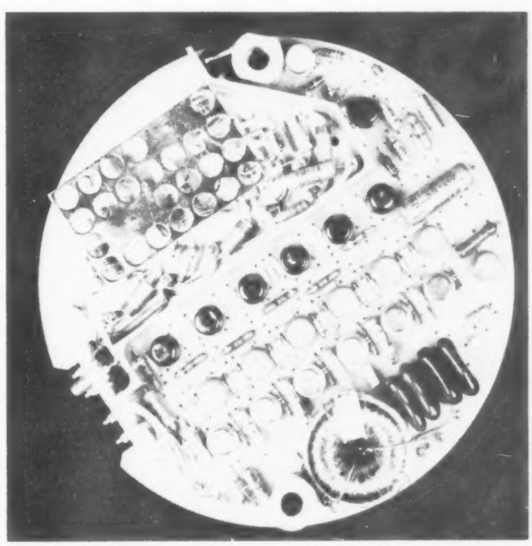
Shown here and in color on the cover, Explorer VII strikingly demonstrates the technology of payload microminiaturization, the technical skill which is keeping the U.S. in the space stakes. The all-transistorized communications system, for instance, is smaller than a table radio, yet contains as many components as 10 domestic television receivers. The system employs two transmitters, one solar cell powered and operating at 20 mc, and one battery powered and broadcasting on 108 mc (to give a good tracking signal). The interesting solar-cell array was developed cooperatively by Army Research and Development (CONTINUED ON PAGE 76)



A partially disassembled Explorer VII shows the scope and compactness of its equipment.

Weight Breakdown

Battery supply	15.682 lb
Solar cells	18.044
Instrument package	14.283
Separation device	2.750
Detectors and sensors	2.968
Balancing weights	0.816
Antenna systems:	
108 mc	2.172
20 mc	3.490
Paint and rockide coating	0.728
Potting and wiring	1.122
Structure	29.453
Total	91.508 lb



The 5-in. diam 108-mc transmitter package, which contains a six-channel multiplexer and a subcarrier oscillator, shows the stunning compactness of microminiaturized equipment.

Synthesis of storable rocket fuel during space missions

Chemical synthesis of storable rocket fuel from food and respiratory byproducts offers an attractive alternative to a closed ecological system for space missions

By Eugene L. Colichman

SPACE TECHNOLOGY LABORATORIES, LOS ANGELES, CALIF.

Eugene L. Colichman is a member of the technical staff of the STL Propulsion Research Dept., participating in catalytic and photochemical research related to propellant development. After receiving a Ph.D. in physical chemistry from UCLA in 1944, he did university teaching and research for about six years and then, over the past decade, turned his attention to radiation and propulsion chemistry in industry. Dr. Colichman is author of some 40 technical publications, mainly in electrochemistry, and several patents in the nuclear reactor field. He notes that H. R. Lawrence, formerly associate director of STL's Astrovehicles Lab, and currently vice-president, United Research Corp., originally proposed the possibility of the system he discusses and contributed many ideas for it.

MODERN space technology will soon require a method for sustaining man in space for lengthy periods. The solution of this problem will require the application of mass-conservation principles. In the field of space cabin development, it is generally considered that a closed ecological algae system, producing both food and oxygen, will be required for extended periods of human space travel. However, maintaining the proper ratio of carbon dioxide to oxygen in a closed ecological system will be difficult over long periods of time, due to both the inherently slow rate of waste conversion in the algae process and the high probability that at least some inhibition will occur. At best, the method is cumbersome and unattractive. Even assuming ultimate development of a high degree of reliability in the method, an auxiliary supply of oxygen will be required to prevent carbon dioxide-oxygen imbalance, and the algae system will provide only part of the food required by the space crew.

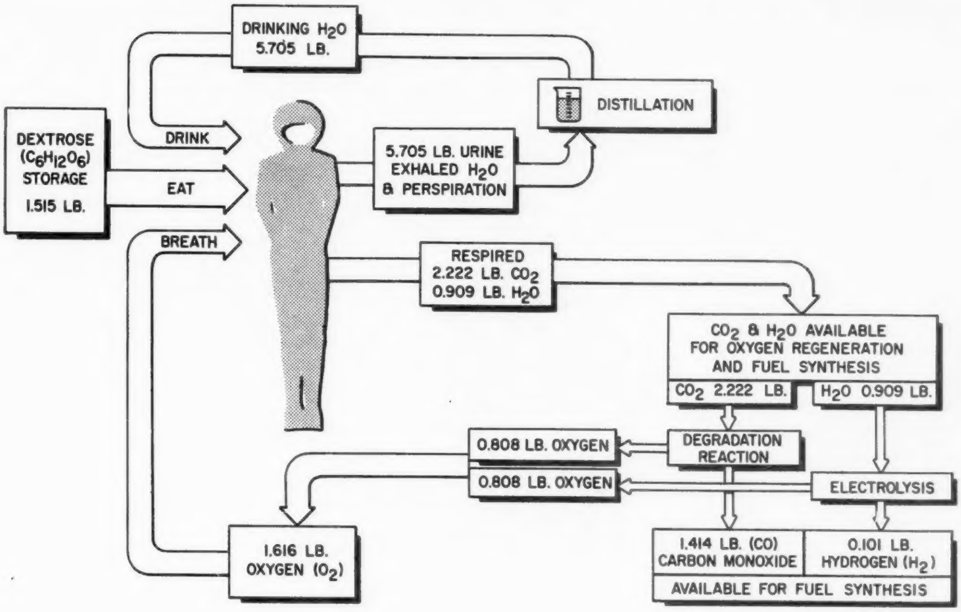
Alternative to Closed Ecological System

There is, fortunately, at least one major alternative to the closed ecological algae system for sustaining man in space for long periods of time. The alternative takes this approach:

1. Carry sufficient food so that biological regeneration (algae process) can be discarded completely.
2. Regenerate needed oxygen continuously from exhaled carbon dioxide and water by simple radiolytic or chemical degradation.
3. Save byproducts from the oxygen production and convert these materials into storable fluids to complement normal rocket fuel in the propulsion process.
4. Decrease initial load of rocket fuel carried as much as possible to counterbalance the additional weight carried as food. The extent to which the weight reduction in normal rocket fuel can be made to equal the sum of the extra food weight and the weight of the fuel manufacturing equipment will depend on the total impulse that can be realized from the byproduct propellants.

To appraise this situation, the system shown on page 33 has been chosen as a model for studying the extent to which maximum total impulse can be achieved from degraded fuel products of carbon dioxide and water while sustaining one man in space for one year by

Scheme for Daily Regeneration of Man's Oxygen and Water Requirements



carrying minimum extra weight in the form of food. The food for the study is dextrose ($C_6H_{12}O_6$) and the weight of other needed food supplements, such as vitamins and minerals, is assumed negligible. The scheme represents the idealized cyclic process that must be maintained each day to sustain a man, based on the following limiting factors:

1. Respiration reaction: $C_6H_{12}O_6+6O_2=6CO_2+6H_2O$ (complete conversion).
2. Dextrose ($C_6H_{12}O_6$) needed determined stoichiometrically equivalent to oxygen intake in respiration reaction.
3. Oxygen intake required per day determined from CO_2 exhaled, neglecting the relatively small quantity of oxygen in waste products. Value used for CO_2 exhaled per day is 1008 grams and water intake and elimination per day is taken as 3000 grams (from "Environmental Problems Connected with Space Ship Occupancy" by W. T. Ingram, Proc. Am. Astronautical Soc., Third Annual Meeting, Dec. 7, 1956, New York, N.Y.).
4. Drinking water is produced by distilling perspiration, respired water, and urine in a continuous cycle (again using Ingram's figures).

A consideration of the following reactions indicates that, during each complete cycle involving consumption of one molecule of dextrose, six molecules of needed oxygen are regenerated for breathing and six molecules each of carbon monoxide and hydrogen are formed for the production of liquid propellants.

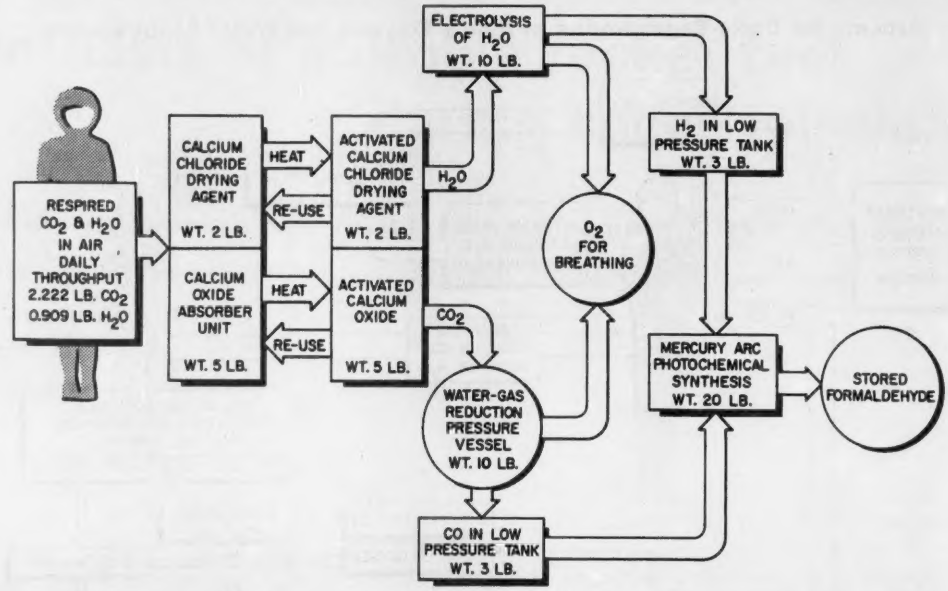
1. Respiration reaction: $C_6H_{12}O_6+6O_2=6CO_2+6H_2O$.
2. Degradation reaction: $6CO_2=6CO+3O_2$.
3. Electrolysis reaction: $6H_2O=6H_2+3O_2$.

This equimolar ratio of carbon monoxide and hydrogen gas formed in the regeneration cycle suggests three possible processes for liquid-propellant production from byproduct gases. The table on page 34 gives these three processes.

Process 1 is favored, since the production of formaldehyde consumes carbon monoxide and hydrogen in exactly equimolar quantities. Process 2 requires the addition of one-half molecule of hydrazine per each molecule of carbon monoxide and hydrogen formed in the regeneration scheme. Similarly, Process 3 requires the storage of water to furnish a molecule of water per each molecule of carbon monoxide and hydrogen formed in the regeneration scheme. The oxygen in the water actually counterbalances an equal weight of oxygen in the oxidant, so storage of each water molecule amounts to storing a molecule of hydrogen.

The table on page 35 shows that the fuels produced in all three processes yield nearly comparable specific impulse (209–215 sec with optimum nozzle expansion at sea level). The total impulse per man-

60-lb System for Producing Formaldehyde from One Man's Food Requirements



year from food-produced fuel in the oxygen-regeneration cycle is also comparable in the three processes, amounting to 154,000–160,000 lb-sec.

Process 1 Seems Best

Accordingly, Process 1 appears the most logical at this time, and a preliminary estimate of the minimum mass involved in carrying out this process in space has been made. The figure shown above illustrates Process 1 and gives results of the estimate. It is to be noted that formaldehyde, methanol, and methane are all possible products from the reaction between carbon monoxide and hydrogen. By selecting a suitable catalyst and temperature, any of these three substances may be produced selectively.

"Bibliography of the Fischer-Tropsch Synthesis and Related Processes, Parts I and II," by H. C. Anderson, J. A. Wiley, and A. Newell (Bureau of Mines Bulletin 544, U.S. GPO, Washington, D.C., 1954) summarizes the many reports and patents dealing with Fischer-Tropsch reactions. A consideration of this publication indicates that the following three methods for producing formaldehyde from carbon monoxide and hydrogen give good yields. Method 1 has been chosen as the basis for the weight analysis in the figure above.

Method 1: Photochemical reaction between carbon monoxide and hydrogen (sensitized by mercury-vapor to light of wavelength 2537 Å from a

Processes for Producing Liquid Propellants

(1) $CO + H_2 \xrightarrow{\text{catalyst}} CH_2O$ (formaldehyde)

(2) $\frac{1}{2}CO + H_2 \xrightarrow{\text{catalyst}} \frac{1}{2}CH_3OH$ (methanol)

$\frac{1}{2}CH_3OH + \frac{1}{2}CO + \frac{1}{2}N_2H_4$ (stored hydrazine)——modified Fischer-Tropsch synthesis

or

$CO + H_2 + \frac{1}{2}N_2H_4$ (stored hydrazine)——modified Fischer-Tropsch synthesis

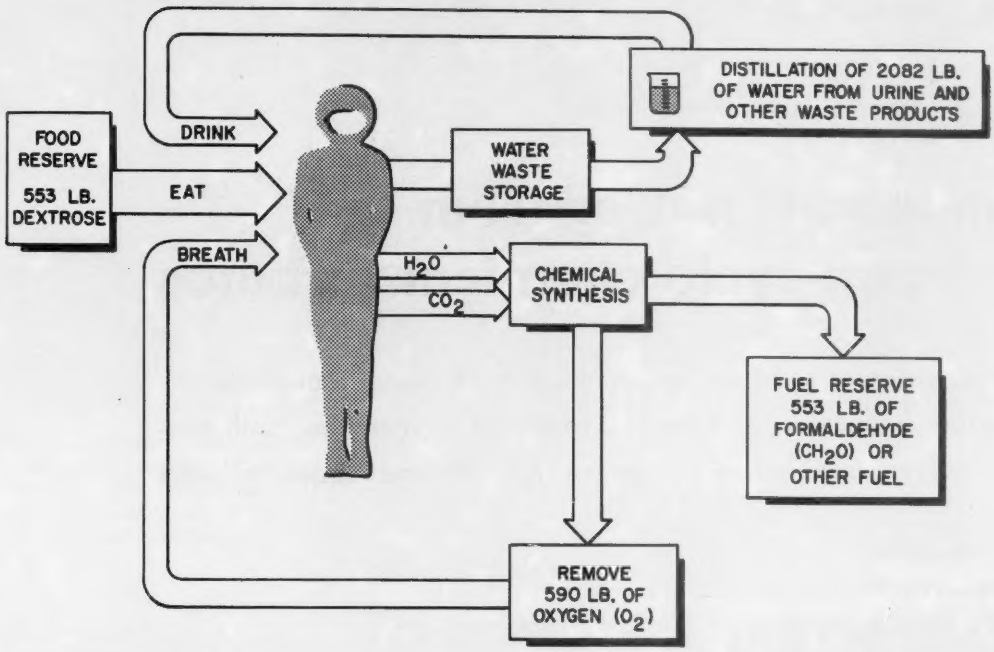
} liquid fuel mixture*

(3) $CO + H_2O$ (stored water) $+ H_2 \longrightarrow CH_3OH$ (methanol) $+ \frac{1}{2}O_2$

$\frac{1}{2}O_2 + N_2O_3$ (stored mixed nitrogen oxides) $\longrightarrow N_2O_4$

* Empirical average formula, CH_4NO, considered to be an equimolar mixture of urea and methanol for impulse calculations.

Over-all Scheme for Food-Fuel Process for One Man-Year



water-cooled mercury arc), producing formaldehyde in yields of about 70 per cent. ("Formaldehyde from Carbon Monoxide and Hydrogen" by H. Church, French Patent 519,649, 1919.)

Method 2: Formaldehyde is obtained by passing a mixture of molecular amounts of dry hydrogen chloride, carbon monoxide, and hydrogen at 200–300 C over catalytic quantities of a mixture of copper chloride, copper, iron, and nickel. Formic chloride forms as the intermediate product, and then is decomposed by the hydrogen to formaldehyde and hydrogen chloride. The reaction takes place almost quantitatively at relatively low velocity. ("Formation of Formaldehyde from Water Gas in the Electric Glow Discharge" by A. Koenig and R. Weinig, *Chem. Abstracts*, vol. 21, 1927, page 3834.)

Method 3: It is possible to obtain formaldehyde as the chief product of the action of glow (silent) discharge on water gas (carbon monoxide and hydrogen), so that up to 77 per cent of the gas treated can be recovered as formaldehyde. The maximum yield of formaldehyde was obtained when the incoming gas contained 46 per cent carbon monoxide by volume. Calculated on the basis of the electric energy consumed, the yield was 2 grams of formaldehyde per kilo- (CONTINUED ON PAGE 80)

Impulse Available from Liquid Propellants Produced from Food Wastes During a Man-Year Regeneration Cycle

Fuels for each process as given correspondingly in table on page 34; oxidizer for each process the same, N_2O_4.

	Process 1	Process 2	Process 3
I_{sp} for optimum expansion at sea level (P_c = 300 psia), sec*	209	212	215
I_{sp} in space for large nozzle (P_c = 300 psia and E = 37), sec	279	282	290
Fuel produced per man-year, lb	553	848	590
Hydrazine carried, lb	—	295	—
Hydrogen furnished by water carried, lb	—	—	37
Oxidizer carried, lb	424	939	1043
Fuel from food per man-year, lb	553	553	553
Total impulse, lb-sec	273,000	504,000	474,000
Impulse from food-to-fuel, lb-sec	154,000	156,000	160,000

* I_{sp} estimates by S. A. Johnston of STL.

Spacecraft power from open-cycle chemical turbines

Turbine generators driven by combustion of such propellants as hydrazine, hydrogen peroxide, and hydrogen-oxygen offer both auxiliary power and heat-sink cooling for manned space vehicles

By Antonio Orsini

WALTER KIDDE & COMPANY, INC., BELLEVILLE, N.J.

Antonio Orsini is manager of new product development for Walter Kidde, which he joined as an engineer in 1944, after two years on the design and development of liquid-air and -oxygen plants at M. W. Kellogg Co., work which he came to on receiving a degree in mechanical engineering from Cooper Union in 1942. In 1949, he became project engineer for the development of a hydrogen-peroxide driven auxiliary power system for missiles, and has since kept active in the field of secondary power supplies. From 1953 to 1957, he was in charge of the development of ethylene oxide and hydrazine driven auxiliary power systems for Navaho.

SOME manned space vehicles will profit from chemically fueled open-cycle secondary power systems rather than other sources of auxiliary power, such as batteries, fuel cells, solar cells, and closed-loop systems with solar, nuclear, or chemical heat sources.

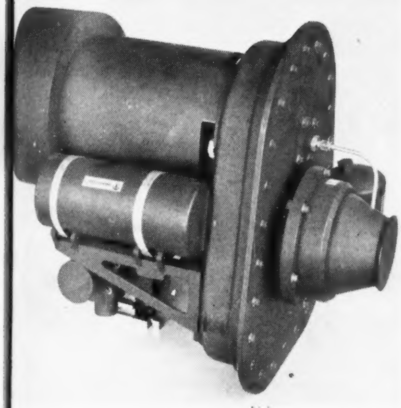
Relatively simple space capsules are probably best served by batteries. For true spaceflight, however, with capability for maneuvering upon re-entry, power levels rise rapidly, and other means of providing secondary power must be utilized.

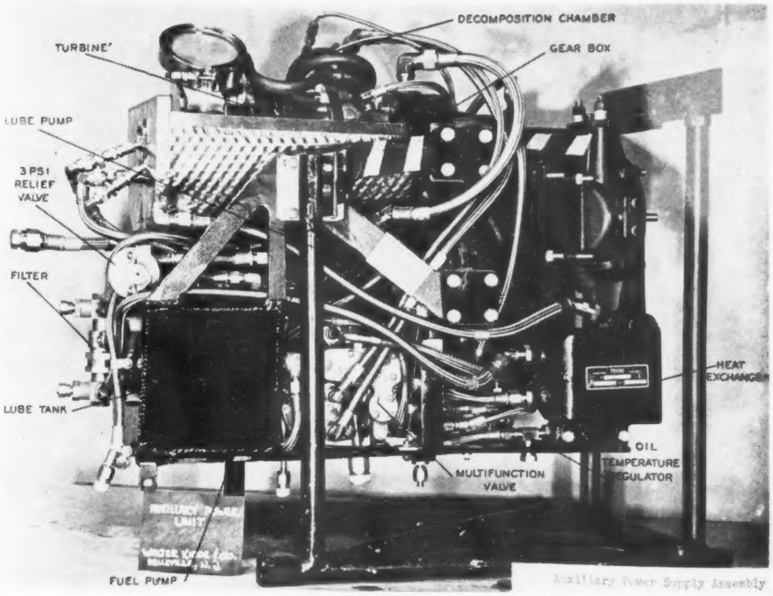
The ultimate power supply for long manned spaceflights appears to be the nuclear closed loop. However, it also seems likely that manned vehicles for long flights will employ a chemical system, both to carry peak loads during launch and re-entry and to eliminate the need for reactor operation close to the earth's surface. In addition, a manned vehicle with a nuclear system will require shielding weighing many thousands of pounds. It may thus prove advantageous in terms of weight in some missions to employ a chemical system, rather than a nuclear one with massive shielding, to provide auxiliary power.

But it is not our purpose to define the operating regime for the chemically fueled open-cycle system. Rather, our aim is to define the present and future capabilities of the chemically fueled open-cycle system in quantitative and realistic terms, so that a vehicle designer will have some guide for planning its use.

Our discussion considers three likely fuels for future long-running secondary power sources—anhydrous hydrazine, hydrogen peroxide, and oxygen-hydrogen. The monopropellants hydrogen peroxide and hydrazine can now be used with a high degree of confidence, based upon extensive work by several groups. The hydrogen-oxygen bipropellant system is somewhat newer, but there does not appear to be any serious obstacle to its use. Gas generators and turbines with this propellant system have functioned reliably in repeated tests under steady-state, continous-duty conditions in programs conducted by the writer.

Other propellant systems which either have been or might be used in open-cycle secondary power systems are solid propellants,





The above photo shows an advanced design of an open-cycle secondary power unit. Right, uncowled, a typical unit designed to withstand severe environmental conditions.

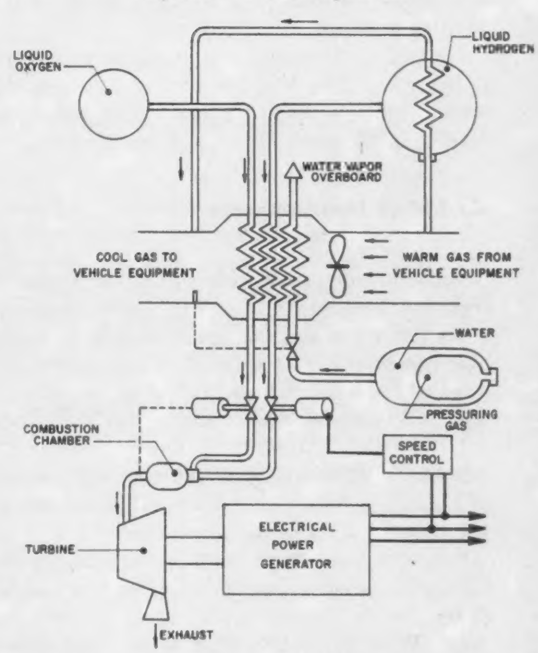
ethylene oxide, propyl nitrate, and bipropellant such as hydrogen peroxide-hydrazine, hydrogen peroxide-diesel fuel, etc. However, ethylene oxide, propyl nitrate, and the solid propellants are not considered basically suitable for very long-duration applications; and, in any case, the propellant consumption would be greater than that for the hydrazine system. It should be noted that bipropellant systems achieve their high impulses and available energies at gas temperatures too high for uncooled prime movers operating continuosly. To reduce temperatures, it is necessary to operate at non-stoichiometric conditions, which bring no advantage over good monopropellant performance. An outstanding exception is the oxygen-hydrogen system, of which more in a moment.

Basic Considerations

In evaluating propellant systems, two basic considerations are (1) the energy available from expansion of the gases through some pressure ratio and (2) the temperature of the gases from combustion or decomposition. Plotting specific impulse versus temperature for various propellant systems gives the lowest curve on the graph at the top of page. 74. Hydrazine performance plotted on the same graph shows a much higher impulse than this "mix" of propellant systems, owing to lower average molecular weight of hydrazine combustion products.

In general, it takes high temperature to get high performance from the propellant. The oxygen-hydrogen system, however, offers an exceptional performance. The energy (CONTINUED ON PAGE 72)

Space Vehicle System



TYPICAL SYSTEM SCHEMATIC
O_2-H_2 FUELED OPEN CYCLE POWER SYSTEM

Could the satellites of

An examination of their extremely small size, proximity to the planet, and peculiar orbits has led a well-known Soviet scientist to the somewhat startling conclusion that Phobos and Deimos are of artificial origin

THE WELL-KNOWN Soviet physicist and mathematician I. S. Shklovsky some months ago advanced a new and startling hypothesis on the nature of the satellites of Mars. What follows is an interview Dr. Shklovsky had with a *Kosmomolskaya Pravda* correspondent relative to this theory.

Question: What does modern science know about the satellites of Mars?

Answer: The two small satellites of Mars—Phobos and Deimos (Fear and Terror)—were discovered in 1877 by the American astronomer Hall. Phobos, which is closest to Mars, moves over an almost circular orbit with a radius of 9476 km, that is, at a distance of about 6000 km from Mars. It completes one revolution around Mars in 7 hr 39 min; the Martian day lasts 24 hr 37 min.

Deimos also moves over a circular orbit with a radius of 23,500 km, completing one revolution around Mars in 30 hr 18 min. Both baby moons revolve in the plane of the Martian equator.

No Direct Measurements

Unfortunately, even with present-day optical observation techniques it is impossible to measure from the earth the diameters of Mars' satellites. The dimensions of the Martian moons are calculated on the basis of their brightness, assuming that their reflecting capacity equals that of Mars (which is 15 per cent). According to these calculations, the diameter of Phobos is approximately 16 km and that of Deimos is 8 km. There are no direct measurements of the mass of the Martian moons.

Briefly, this is all that science knows today about the satellites of our neighbor planet in the solar system.

Q: What makes the Martian satellites different from those of other planets?

A: First, their extremely small dimensions. Apart from the earth's artificial satellites, no other planet has such tiny moons. Second, their extreme proximity to their planet. The period of revolution of Phobos, shorter than the rotation period of its planet, is an absolutely unique phenomenon in our solar system.

In turn, all cosmogonic hypotheses failed to explain the origin of such strange satellites. Should we consider them, for instance, to be asteroids accidentally captured by Mars, then it is incomprehensible that they should move over nearly circular orbits, lying precisely in the equatorial plane.

Phobos Is Deviate

One of the Martian satellites has another striking feature, distinguishing it from all other satellites in the solar system. In 1945, Sharples, an American astronomer, carried out a series of observations of the satellites of Mars and compared the data obtained with earlier ones, in particular with the data based on observations made at the beginning of this century by the Russian astronomer German Struve. The latter calculated with great accuracy the position of the satellites in their orbits at any particular moment, proving that the theoretically expected position of Phobos deviated from the actual one. And the divergence was extremely great. In just a few decades, Phobos moved as much as 2.5 deg away from the point in its orbit where, according to calculations, it should have been! An incomprehensible fact—simply a scandal in celestial mechanics!

Since Phobos accelerated its movement during this period, that means that it has drawn nearer to the surface of Mars. This is exactly what is happening to the artificial earth satellites. Atmospheric resistance is retarding their movement; they descend progressively, and at the same time their movement is accelerated.

The changes in the nature of the movement of Phobos are so great that we may say with confidence that we are witnessing the slow agony of a celestial body. It means that, in just a mere 15 million years, Phobos will fall on Mars. Astronomically speaking, this is a relatively short period.

Q: How do astronomers explain the retardation of Phobos? (CONTINUED ON PAGE 52)

Mars be artificial?

A leading American planetary astronomer examines the Soviet hypothesis and finds good and sufficient reason for doubting that the Martian moons are anything other than natural bodies

By Clyde W. Tombaugh

RESEARCH CENTER, NEW MEXICO STATE UNIV., LAS CRUCES, N.M.

IT IS commonly stated and accepted that the satellites of Mars, Phobos, and Deimos are 16 and 8 km (10 and 5 miles) in diam, respectively. These values are based on an assumed albedo of Mars, namely 15 o/o. But Mars has an atmosphere, whereas the satellites are much too small to hold the slightest gaseous envelope. It would be more reasonable to assume a lower albedo for these satellites, similar to earth's moon and Mercury, namely 7 per cent, which is rather characteristic of atmosphereless bodies. Such a value would raise the diameters to 23.4 and 11.7 km ($14^1/_2$ and $7^1/_4$ miles), respectively.

Shapes Approximately Spherical

Let us suppose that the surfaces of the Martian satellites consisted of some strong metal. Inevitably, the surface would be pitted to a matt quality by small meteorites over a long period of time. In this case, an albedo of 70 per cent might be of the right order. Hence the diameters would then be 3.16 times less, or 7.4 and 3.7 km (4.6 and 2.3 miles) respectively.

I have found no reference to any observed fluctuation in the brightness of either satellite. Therefore, one may tentatively conclude that their shapes are approximately spherical. During my long search for transNeptunian planets, over 1500 asteroids were encountered. Only a small fraction of them exhibited variation in light, indicating that they were either very irregular in shape or spotted. The variable asteroid, Eros, was actually observed in a powerful telescope visually by van den Bos and Finsen in 1931 to exhibit a much elongated shape and to show rotation. Therefore, Mars' satellites seem to exhibit the characteristics of an average asteroid.

The startling hypothesis by Dr. Shklovsky that the two satellites of Mars are artificial in origin is very difficult to accept for two reasons: (1) To put up two multimillion-ton satellites would severely strain the economy of a civilized society rich in natural resources; (2) studies of the physical conditions on Mars indicate the planet is decidely unfavorable to the development of an animal species capable of attaining a technological civilization. The information presented on physiological processes under such conditions by Hubertus Strughold in his book "The Green and Red Planet" are most pertinent. Even if a suitably intelligent race of beings could have evolved, the extreme poverty in mineral resources on Mars would have deprived them of the necessary materials.

In my article in the January 1959 issue of *Astronautics*, entitled "Mars—A World for Exploration," geological conditions are deduced from certain observational features and behavior.

The size of a planet and its distance from the sun profoundly affect its geology, which in turn, is decisive in producing climate and mineral resources.

No Oceans of Water

Percival Lowell and others have advanced the theory that Mars once had oceans of water which slowly vanished from the planet. It is generally overlooked that Mars would have been permanently and heavily glaciated with so much water because of the low mean annual temperature. The manner of the annual seasonable dwindling of the summer polar cap and temperature measurements with the thermocouple suggest that only by the mixing of warmer air from adjacent regions at the cap's edge does the cap retreat. Mars is too far from the sun to allow melting of the polar caps by straight insolation falling on a white (CONTINUED ON PAGE 54)

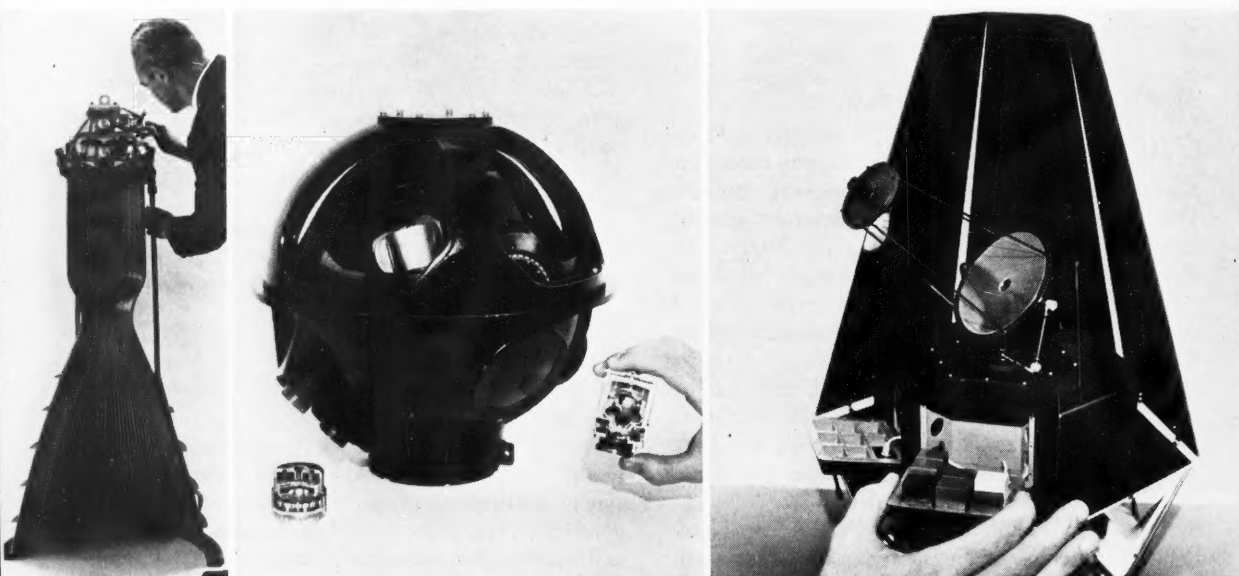
NASA age one

NASA's 1959 Inspection reveals the scope of research and engineering programs by the nation's civilian space agency

THE National Aeronautics and Space Administration's 1959 Inspection, held at Langley Research Center in October, proved an eye-catching and smoothly run affair, and incidentally an impressive platform for a NASA bid for additional funds to support certain key programs, such as the Nova project, which evidently suffered from the $30 million Congressional crimp in the space agency's budget.

The Inspection represented each of NASA's major facilities, except the newly acquired ABMA team: Langley, Ames, and Lewis Research Centers, the Jet Propulsion Laboratory of CalTech, Goddard Space Flight Center, Wallops Station, and the Flight Research Center at Edwards, Calif.

A few highlights of the Inspection: Langley's panoramic display of Project Mercury hardware and test results, especially the successful Little and Big Joe shots this fall; Langley and Ames' engineering studies of winged hypersonic vehicles, which are following the general approach described by George Gerard in the August 1958 *Astronautics;* Lewis's systems analyses of interplanetary vehicles and associated experimental work on ion and plasma propulsion, this latter in cooperation with Langley; GSFC's developing program of satellite geodetic studies and rocket astronomy; FRC's flight-testing of the X-15; Ames' experimental studies of sputtering and meteoritic damage to space vehicles; Langley's studies of signal (CONTINUED ON PAGE 80)

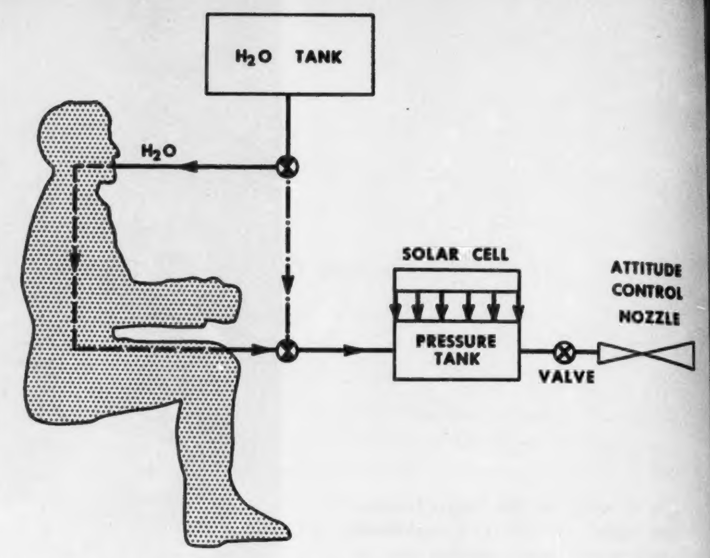


Left, JPL engineer checks valves at top of cutaway full-scale model of 6000-lb-thrust storable liquid-fuel engine which will make up the third stage of NASA's Vega vehicle. Center, part of Vega guidance system developed by JPL: Inertial reference unit is made up of stable platform (center) containing three accelerometers and three gyros; cutaway accelerometer and gyro models are shown (left and right). Right, one-third scale model of JPL's proposed Mars payload for Vega. Hexagonal base contains six chassis (two shown opened), each with blocks of electronic components. Above the base is IR spectrophotometer; telescopic mirror arrangement will collect light rays from Mars for analysis and transmission to earth while payload orbits. Package also has six solar panels which fold out to gather energy from the sun.

Six or more of the cargo boosters (at right) would carry payloads containing parts needed to assemble the four-stage chemical-rocketship (at left) in an earth-satellite orbit. The ship, a Lewis Research Center hypothetical design, would carry an eight-man crew and auxiliary vehicle on a round trip between earth and Mars satellite orbits.

Flight-package version of 100-ft sphere developed under Langley Research Center inflatable satellite program. Slated for early launching, the sphere is inflated automatically in space, has potential application as lunar probe.

Heavy bow shockwave characterizes this Mercury capsule model launched at Mach 3 by high-speed gun and flying through instrumented range at Ames Research Center. Optical distortion causes seeming bulge at forward rim of model; capsule is actually smoothly curved. Serrated portion at right is part of gun-launching sabot, not capsule design.



HUMAN LIQUID WASTE UTILIZATION FOR SHORT-PERIOD ORBITAL MISSIONS

Water rockets

Designers show renewed interest in the potential usefulness, simplicity, and cheapness of hot-water and steam rockets

By Denis J. Zigrang
THE MARTIN CO., DENVER, COLO.

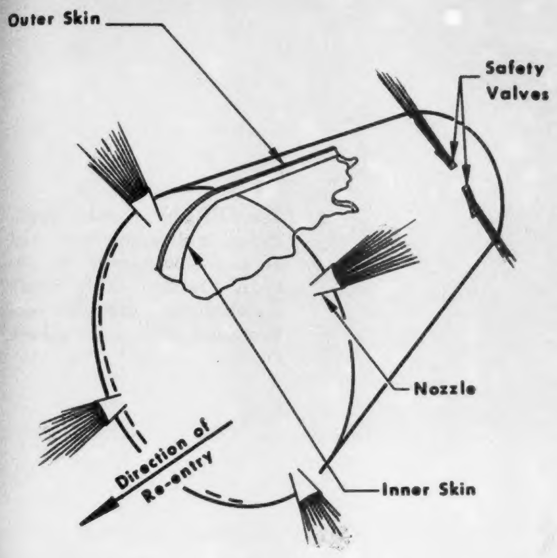
Denis J. Zigrang is a design engineer in the propulsion section of Martin-Denver. His work is largely concerned with propulsion for advanced ballistic missile weapon systems. After receiving a B.S. in chemical engineering from Iowa State Univ. in 1949, he did graduate work in that field, then joined North American Aviation to work on nuclear energy and propulsion, and last year became a member of the propulsion staff of Martin. He is the author of a number of papers in the field of propulsion thermodynamics.

IN THIS age of high-energy solid-and-liquid propellants, a significant amount of interest is being shown in a remarkably low-energy propellant — water. It is hard to imagine a cheaper, more abundant propellant material. Heated electrically, or perhaps by nuclear energy, water can perform a number of propulsion tasks more economically than any other propellant. The cost for developing and producing hot-water or steam rockets is estimated to be 95 per cent less than for chemical-propellant counterparts. Water has been of interest to the propulsion engineer for centuries, and continues to be of interest to him in the Space Age.

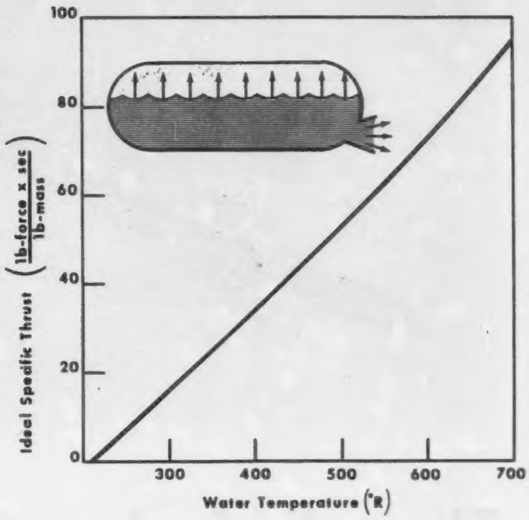
When water is used in the liquid state in the hot-water rocket, a specific thrust of perhaps 60 lb-force/lb-mass/sec is obtainable. In applications where the low density of steam is not objectionable, a specific thrust two to three times that of the hot-water rocket can be realized. At the high temperatures and power levels attainable in nuclear reactors, specific thrust levels approaching those of today's high-energy chemical propellant systems can be obtained.

Historically, the hot-water rocket dates back to 1824, when an Englishman, James Perkins, patented the device as an interesting toy. After loading his rocket with water, Perkins sealed the nozzle throat with a low-melting alloy. Placed in a bonfire, the rocket fired when the alloy melted.

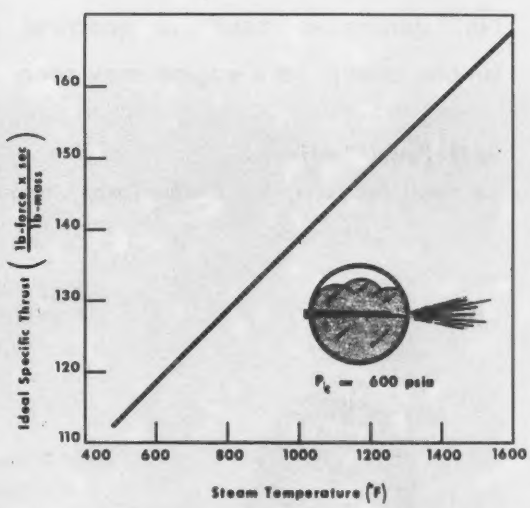
After Germany emerged again as a world power in the 1930's, interest was renewed in the water-powered rocket. As early as 1939, a hot-water rocket was used to drive a rocket sled to Mach 1.2.



Attitude Control on a Re-entry Vehicle



Ideal Sea-Level Performance of a Hot Water Rocket



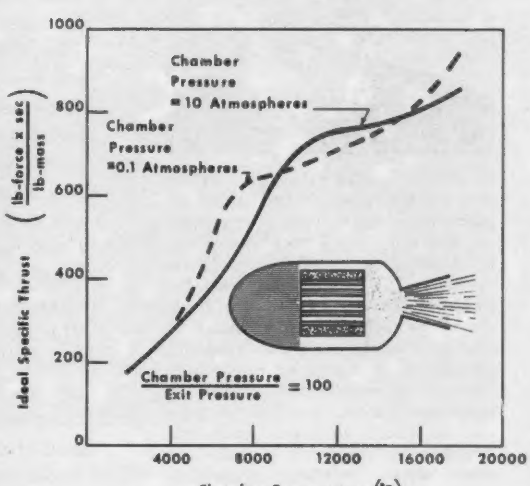
Ideal Sea-Level Performance of a Steam Rocket

During WW II, the Germans employed the hot-water rocket as a Rato device in connection with the ME-262. Security prevented the publicizing of this event during the war, but technical papers describing German hot-water and steam rocket work have appeared in many journals since that time.

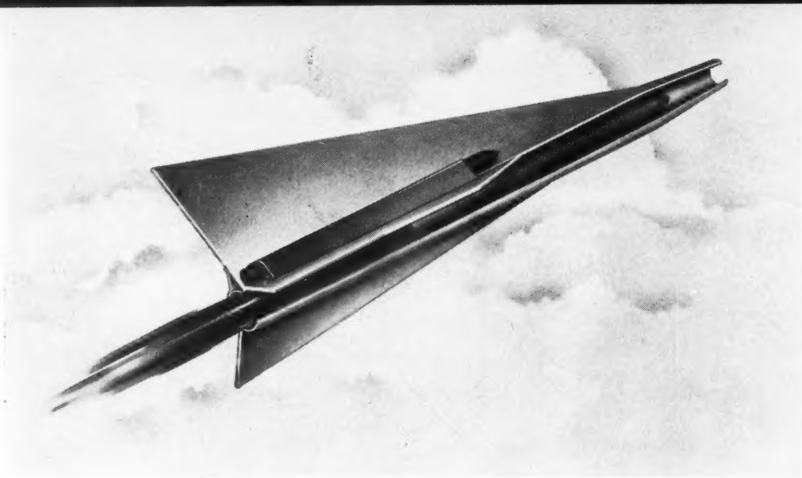
German scientists are currently working on both the hot-water rocket and the steam rocket. Technical publications indicate that serious consideration is being given to the use of water as a working fluid in nuclear rockets. In the field of hot-water rockets, Eugen Saenger is currently developing a 400,000-lb-sec total impulse device at the direction of the German Ministry of Transportation for possible use as a mail and freight rocket. In a recent report about the economics of hot-water and steam rockets, H. H. Koelle declared that the cost of developing such devices is only one-twentieth that of developing chemically propelled rockets of a similar size—probably an excellent reason for the recent increase in interest.

U. S. Interest Increases

In this country, interest has been slow in coming. Robert Truax has suggested the possibility of using steam rockets as sounding devices. Experiment Inc. of Richmond, Va., has reportedly fired several steam rockets in an attempt to test their suitability for meteorological application. The Navy has shown some interest in the Rato application. Dandridge M. Cole recently proposed water as the working fluid for a nuclear (CONTINUED ON PAGE 48)



Ideal Performance of a Water-Powered Nuclear Rocket



The SFRJ has possible application as a target drone and as a missile carrier for air-to-air warfare. This artist's sketch shows a dronelike configuration with a piggyback missile.

The solid-fuel ramjet

Not studied in depth in practical applications as yet, this simple, cheap, safe engine may soon power missiles and drones

By H. Powell Jenkins Jr.

U.S. NAVAL ORDNANCE TEST STATION (NOTS), CHINA LAKE, CALIF.

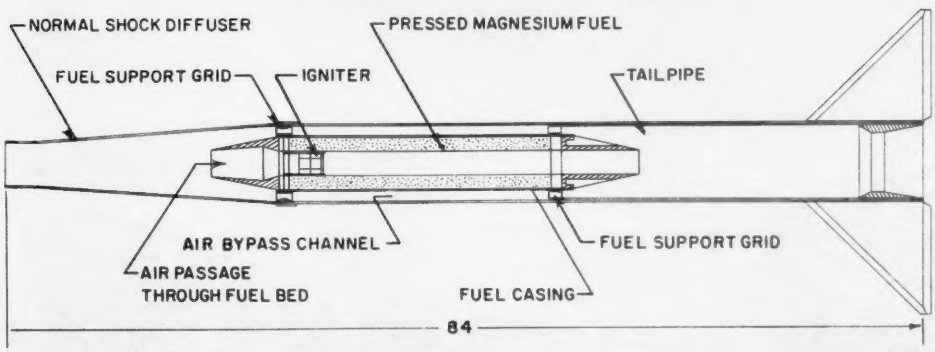
H. Powell Jenkins Jr. is head of the Propulsion Research Branch of NOTS, which he joined in 1946 after serving as an ordnance officer in the Navy. By training a chemist, having received a B.S. in chemistry from the Univ. of North Carolina, his background in rocketry includes basic research in combustion and explosive phenomena and applied research in liquid, solid, hybrid, and airbreathing propulsion systems at NOTS. At present, he directs programs on hybrid rockets, the solid-fuel ramjet, and other forms of advanced propulsion.

THE SIMPLEST appearing engine ever invented by man is the solid-fuel ramjet (SFRJ). Here is the proverbial "flying stovepipe" with a briquette of fuel burning in it. It has no pipes, no valves, no flameholders, no injection orifices—nothing but a pipe with a chunk of fuel in it. The solid-fuel ramjet can attain a range two or three times that of a comparable-sized rocket in flight through the atmosphere. It is safe; it is inexpensive; it can fly at high-supersonic speeds. But it has never been used in a single piece of operational ordnance. Why?

The drawing on the opposite page illustrates a typical experimental SFRJ. As is true of any ramjet, it must be boosted to operating speed by outside means, such as a separable rocket booster. Flying at its design speed (Mach 2 in this design), it operates with efficiency. Air at Mach 2 is rammed through the normal shock and into the diffuser. There the air is decelerated and consequently compressed. At the entrance to the fuel section, the air may be going only 200 or 300 fps.

Fuel consists of a hollow cylinder of pressed magnesium powder or other fuel, such as a hydrocarbon. The fuel cylinder is inhibited from burning on all surfaces except on the interior perforation. Part of the incoming air passes through the interior of the burning charge; most of the air is bypassed around the outside of the fuel. The air passing through the center allows only incomplete combustion of the fuel, and the air stream then carries the fuel-rich products into the tailpipe, where combustion is completed by mixing with the previously bypassed air. The thermal energy from combustion accelerates the gas out of the nozzle, and reaction produces thrust in the engine.

Typical Experimental Solid-Fuel Ramjet



The spilt-flow combustor just described has several advantages. A cool layer of air is maintained along the tailpipe, thereby largely avoiding problems of tailpipe burnthrough. Perhaps most important, however, is that by allowing only a small flow of air past the burning surface, it is possible to eliminate erosive burning. This, coupled with the improved combustion due to mixing with the large volume of air that had been bypassed, results in combustion efficiencies approaching 90 per cent.

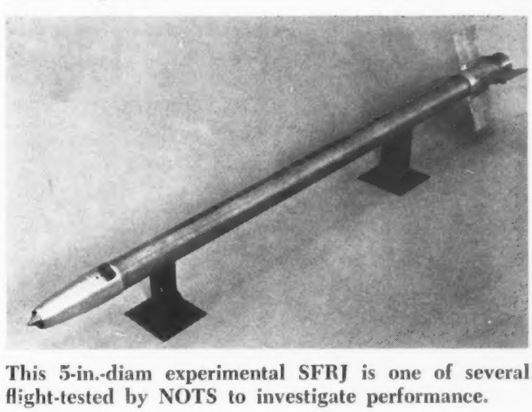
SFRJ Compared to Rocket

A well-designed SFRJ can achieve a range from two to three times that of an equivalent-sized rocket under conditions in which ramjets can perform most efficiently. By not carrying its own oxidizer, the SFRJ substantially outperforms a rocket. A ramjet probably has to fly a minimum of about 10 miles (or farther, depending on altitude) before it can compare favorably with a rocket in terms of weight. The upper limit of range is on the order of 100 miles, because, in most designs, the SFRJ combustion chamber has to provide space for both fuel and air passage. For missions of longer range, a rocket traveling outside the earth's atmosphere on a ballistic trajectory can exceed the range of the ramjet. However, meaningful comparisons are difficult without reference to a specific weapon mission and design.

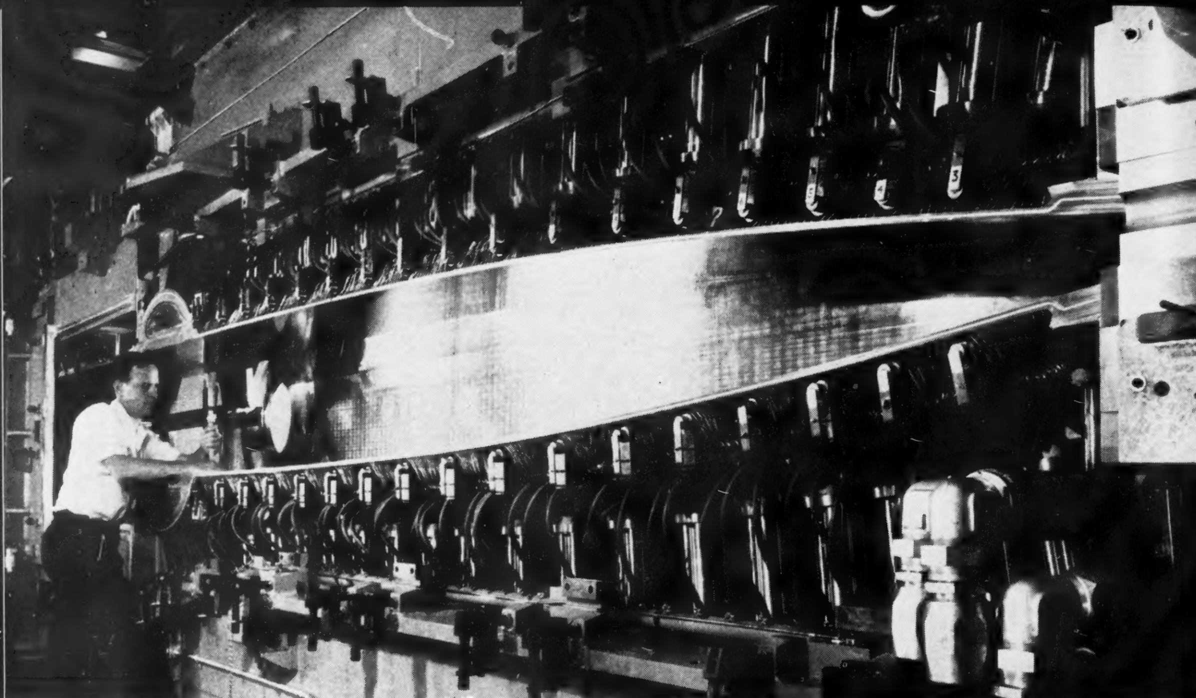
As with other ramjets, the SFRJ's present useful range of speed is probably between Mach 1.5 and 4.5. Ramjets have been operated subsonically, but with low efficiency. The upper limit of Mach 4.5 will undoubtedly be raised as new fuels come into use and as we learn how to make use of the thermal energy now lost to molecular dissociation. A speed of Mach 10, or even Mach 15, is an eventual possibility.

The SFRJ is basically simple and therefore can be made reliable. Like a solid-propellant rocket, it has no pumps, valves, or fuel regulators—not even spray nozzles to become clogged. In most designs, a solid charge is ignited and burns either on one end or inside a simple internal perforation. This is both an advantage and a disad-(CONTINUED ON PAGE 92)

Samples of fuel briquettes for solid-fuel ramjets. Materials such as powdered magnesium and a small perentage of solid oxidizer to sustain combustion are compacted under a pressure of 20 tons to form the dense briquettes.



This 5-in.-diam experimental SFRJ is one of several flight-tested by NOTS to investigate performance.



Nozzle section of JPL's new hypersonic wind tunnel, with throat entrance at right and test section and port by engineer.

JPL's new hypersonic wind tunnel

A unique Mach 5–9 continuous-flow facility gives JPL a key tool for Space-Age missile and vehicle development

AS EXPLAINED by Wallace Hayes in his two-part article on hypersonic aerodynamics (March and April 1959 *Astronautics*), the main theoretical and experimental challenge in aerodynamics now appears in the low-hypersonic range. The $3.5-million continuous-flow wind tunnel recently unveiled by the Jet Propulsion Laboratory gives it one of the first facilities in this country for applied research and development in this range, from Mach 5 to 9.

Developed over the past three years by JPL engineers, funded by Army Ordnance, the new hypersonic wind tunnel, shown in photo and diagram here, features a unique two-dimensional flexible nozzle with a 21-x-21-in. test section. The nozzle throat is made of solid beryllium-copper blocks, cooled by a water system able to carry 1475 gal/min. These blocks can withstand a maximum pressure of 1000 psi at a temperature of 1350 F. The rectangular nozzle throat, shown on page 100, closes to a slit 17 in. wide and 0.045 in. for Mach 9 operation. Flexible steel plates form (CONTINUED ON PAGE 100)

Water Rockets

(CONTINUED FROM PAGE 43)

pulse-rocket ("Possibilities for Economical Spaceflight," *Astronautics*, Sept. 1959, p. 32).

Several astronautical applications for water and steam rockets have been suggested by Walter Kuehnegger of the Martin Company. The sketch on page 42 illustrates one of these—the use of the astronaut's urine as a propellant in a steam rocket that might be employed for attitude control and orbital corrections. Urine is converted into steam by solar heat. The steam is then vented through a suitable rocket nozzle. Should the 1500 cu cm of liquid waste produced daily by the average man not be adequate, the man in the system can be bypassed, as indicated, by the valve. Such a system might be used when only hours or a few days are spent in flight. (It has been suggested jokingly that such a system will save the weight of the psychologist who might otherwise accompany the astronaut to convince him that he must drink his own reprocessed urine.)

The sketch on page 43 illustrates the use of the steam rocket in re-entry vehicles for attitude control during the terminal phase of operation. Water is converted to steam by aerodynamic heating during re-entry. The steam is vented as needed through one or more of four nozzles. Excess steam is vented uniformly through four additional safety nozzles. This system might be superior to stored-gas systems because the working fluid is stored in a dense form under a low pressure.

The hot-water rocket is distinguished from the steam rocket by the fact that water rather than steam is expanded through the nozzle. As the hot water expands through the nozzle, it vaporizes. The water at the nozzle exit may be as much as 25 per cent steam. The fact that much of the energy of the water is used to produce steam, together with the fact that the energy of hot water is considerably less than that of steam, explains the relatively low specific thrust of the hot-water rocket. However, the greater propellant loading density of water makes use of the hot-water rocket much more attractive for the Rato application. The hot-water rocket may contain as much as 0.8 mass fraction of propellant, while a similar steam device might have a mass fraction of propellant of only 0.1. The figure on page 43 presents ideal hot-water rocket performance as a function of water temperature for sea-level expansion. The inset sketch is a schematic representation of the hot-water rocket.

In operation, the chamber of the hot-water rocket is loaded about three-quarters full of cold water. It can then be heated in a variety of ways. The use of electrical heating rods is perhaps the simplest. When heated, the water expands and fills most of the remainder of the chamber. During operation, the thrust level and specific thrust of the device continuously decrease because a portion of the energy of the remaining water must be used to form the steam that occupies the emptied chamber. With proper design, this Rato device can be used many times.

Steam Rocket Performance

In the steam rocket, the steam may condense when it expands through the nozzle. The resulting liberation of the heat of water vaporization can contribute to the performance of the steam rocket in an important fashion. The steam at the exit of the nozzle of a typical steam rocket might contain as much as 25 per cent condensate. In the steam rocket, the steam will probably expand to a supersaturated state before condensation is initiated. Although it may be profitable to select an initial temperature so high that condensation will not occur in the nozzle, it has been shown that the condensation "shock," which results when the supersaturated state collapses, does not seriously affect the performance of the steam rocket ("Thermodynamics of the Steam Rocket," D. Zigrang and A. Widawsky, ARS Propellant Thermodynamics and Handling Conference, Columbus, Ohio, July 20–21, 1959).

The figure on page 43 gives a schematic representation and ideal performance curve for a typical steam rocket. Ordinary tap water is converted into superheated steam through heating the chamber. The energy of the steam is partially converted into directed kinetic energy by expansion through the nozzle. As shown, the nozzle throat also serves as the port of the control valve. The chamber is insulated to minimize heat losses, and the nozzle is recessed to prevent damage when the device is dropped. Steam-rocket thrust and specific thrust decrease during the course of a given firing due to decreasing steam pressure in the chamber. The figure shows the ideal performance initially realized for a chamber pressure of 600 psia.

Working fluids for nuclear rockets should have high specific heats and low molecular weights. High effective specific heats may be obtained as the result of dissociation of the working fluid. Sufficiently high temperatures are attainable in nuclear reactors that at least a portion of the superheated steam coming from a reactor would be dissociated, the degree of dissociation increasing with decreasing pressure.

The figure on page 43 presents a schematic representation and performance data for a water-powered nuclear rocket. To illustrate the effect of chamber pressure on performance, data for both 10 and 0.1 atm are presented. In operation, the water propellant is stored in tanks of the rocket vehicle and is pumped into the chamber as needed. After being heated and dissociated in the reactor, the superheated steam is expanded through the nozzle. During expansion, the steam reassociates in an equilibrium manner, the energy of reassociation being converted to directed kinetic energy. Performance data for this form of nuclear propulsion are based on a nozzle pressure ratio of 100 and an ambient pressure equal to the exit pressure of the nozzle.

The simplicity of rocket systems employing water as a propellant, their inherent cheapness of design and development, and their superiority in certain applications will doubtlessly speed their adoption in this country.

Suggested Additional Reading

Koelle, H. H., "About the Economy of Steam Rockets as Jato Units" (In German), Report No. 2 of the Research Institute for Physics and Jet Propulsion, 1955.

Logan, J. G. and Colichman, E. L., "Effect of Dissociation on the Performance of Working Fluids for Nuclear Propulsion, *ARS Journal*, vol. 29, no. 6, 1959, pp 409–413. ◆◆

Research Lab Directory

The NAS National Research Council has in preparation the 11th edition of its unique directory, *Industrial Research Laboratories of the U.S.*, which lists nongovernmental labs devoted to industrial research, including work on processes and products as well as fundamental science. Firms not receiving a questionnaire soliciting information for this directory by Nov. 5, 1959, and wishing to be included in the new edition should inform Walter M. Whitlow, Editor, NAS-National Research Council, 2101 Constitution Ave., N.W., Washington 25, D.C.

Jet and Rocket Combustion Topic of AICE Session

Charles Marcel of NYU will chair a session on problems in jet and rocket combustion at the 52nd Annual Meeting of the American Institute of Chemical Engineers being held Dec. 6–9 at the Sheraton-Palace Hotel in San Francisco. R. Friedman, R. A. Gross, W. T. Olson, and R. S. Levine will present papers.

One of a series

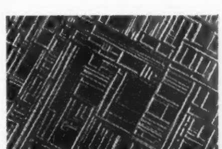
The revealing face of an iron crystal

A single crystal is an ideal system for studying the solid state. Physicists at the General Motors Research Laboratories have turned to whisker-like growths of nearly perfect single iron crystals to investigate three intriguing phenomena: magnetic domains, dislocation defects, and—more recently—high temperature oxidation.

In this latest study, the two crystallographically different surfaces found on iron whiskers are being used to examine the anisotropy or axial-dependent nature of the oxidation process. In early stages of oxidation, the oxide patterns that form on clean surfaces have been found to be strongly dependent upon the orientation of the underlying crystal. In later stages of oxidation, tiny oxide "cilia" actually grow on the surface of the iron whisker. But these new whiskery forms of oxidation are no longer related to the crystal's surface arrangement. The next step in this program involves correlating the oxidation behavior with lattice structure defects such as vacancies and dislocations.

This type of solid state research is revealing the atomic processes underlying strength, magnetic characteristics, and corrosion resistance of metals. At GM Research, we believe the solution to practical problems is increasingly dependent on fundamental information such as this. And each solution enables us to continue to provide "More and better things for more people."

GENERAL MOTORS RESEARCH LABORATORIES

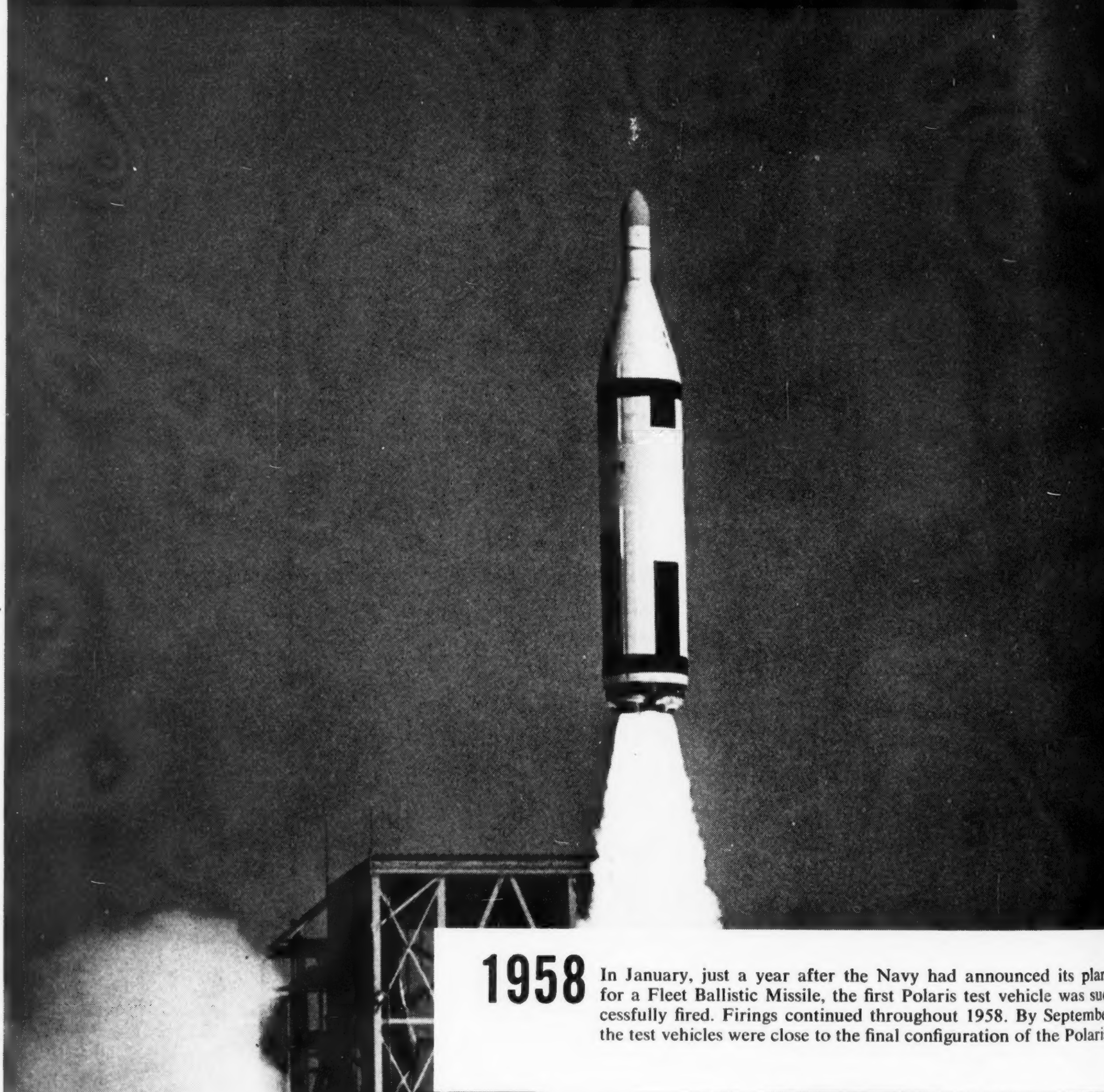


Early Oxidation
(750x)

Oxide Whiskers
(12,000x)

Reduction of Oxide Products
(2500x)

The Log of the Navy's Polaris



1958 In January, just a year after the Navy had announced its plans for a Fleet Ballistic Missile, the first Polaris test vehicle was successfully fired. Firings continued throughout 1958. By September the test vehicles were close to the final configuration of the Polaris.

Mars-Soviet Theory

(CONTINUED FROM PAGE 38)

A: Several works on this subject have appeared in scientific literature abroad. Two possible causes of such retardation have been advanced. First, the resistance of the medium surrounding the satellites—the same thing that retards the artificial earth satellites. If this medium is interplanetary matter (which, generally speaking, might be of a greater density around Mars than it is around the earth), it is incomprehensible why it does not have a retarding effect on the more remote Deimos. But perhaps it is the Martian atmosphere. However, calculations by the prominent American astronomer Whipple jointly with Kell did not confirm this hypothesis.

Another reason for the acceleration of Phobos might lie in tidal action. But since Mars lacks considerable free bodies of water, only the tidal movement in the solid crust of the planet should be taken into consideration. The well-known English astronomer Jeffries, who is the most outstanding expert on tides, recently checked this hypothesis by precise mathematical calculations and found that the tides in the solid crust of Mars could account only for one ten-thousandth part of the observed acceleration of Phobos.

Such are the possible causes of the anomalies in the movement of Phobos which have been considered in scientific literature. But it could be caused by other factors as well.

It goes without saying that one cannot exclude the possibility of a powerful magnetic field existing around Mars, which would have a retarding effect on Phobos. My own mathematical calculations, however, also refute this possibility.

And finally, generally speaking, one cannot exclude the possibility that the acceleration of Phobos occurs in accordance with the laws of celestial mechanics as a result of the influence of the forces of attraction of Deimos, the sun, and other planets. However, according to calculations, these causes should have had a stronger effect upon the movement of Deimos than on Phobos. Actually, the reverse is the case.

Thus I arrived at the conclusion that there are no "natural" ways to explain either the origin of the Martian moons or the oddities in the movement of Phobos.

Q: What is your explanation of these peculiarities?

A: After analyzing and rejecting every conceivable reason for the retardation of Phobos, I came to the following conclusion: It is precisely the retarding effect of the upper, highly rarefied layers of the atmosphere that probably plays the decisive part in this case. But, for this retardation to be so considerable, in view of the extremely rarefied atmosphere of Mars at such an altitude, Phobos must have a very small mass and, hence, an average density of approximately one-thousandth the density of water.

But can a solid body have such a low density, probably less than the density of air? Naturally not! It is, however, possible to visualize Phobos as a cloud of tiny dust particles, at a considerable distance from one another, rather than as a solid body. Calculations show that such a cloud would inevitably be dispersed along its entire trajectory and would become something like Saturn's famous ring. There is only one way of reconciling the requirements of solidarity, invariable shape and the extremely insignificant average density of Phobos: We have to assume that Phobos is hollow inside, something like a can from which the contents have been removed.

Conclusion Drawn

But can a natural cosmic body be hollow inside? No, and again no! Consequently, Phobos is of artificial origin. Consequently, also, Phobos is an artificial satellite of Mars. The peculiarities in the properties of Deimos, although less striking than those of Phobos, justify the assumption that it too is of artificial origin.

Q: Are not the satellites of Mars too large to be of artificial origin?

A: Of course the artificial satellites of Mars are of rather considerable size. Their masses may be equal to 100 million tons or even more. But the creation of such satellites is not an insurmountable engineering problem for thinking beings. It can scarcely be doubted that within a few centuries there will be such gigantic satellites around the earth.

Such satellites, will, of course, be put into orbit at a sufficient distance from the earth—a distance of several earth radii. In that case, their retardation by the infinitely rarefied remnants of the atmosphere and the tides—will be so insignificant that they will survive for hundreds of millions of years, tens of thousands of times more than the entire history of mankind to date. These will be monuments far more durable than the "eternal" Pyramids which are subject to the action of the sun, wind, rain, and cold! Are not, perhaps, the satellites of Mars such monuments of a once-existent highly developed civilization?

Martian nature today can be likened to the nature of a cold plateau elevated to an altitude of 18 km above the earth's surface. Oxygen is almost completely lacking in the atmosphere. I am convinced that there is no longer any highly developed life there. Perhaps there are only the simplest types of plants such as mosses and lichens. But evidently two or three thousand million years ago the situation was different. Many astronomers believe that then there was oxygen in the atmosphere of Mars, while much of its surface was blue with enormous expanses of water—seas and oceans. It was probably then that thinking beings appeared on Mars and attained a high standard of culture. I do not attempt to visualize either their specific shape or what happened to them, but at a definite stage in their development they were bound to go beyond the confines of their planet. Incidentally, Mars has a much smaller gravity than the earth, and, accordingly, spaceflight was much more easily accomplished.

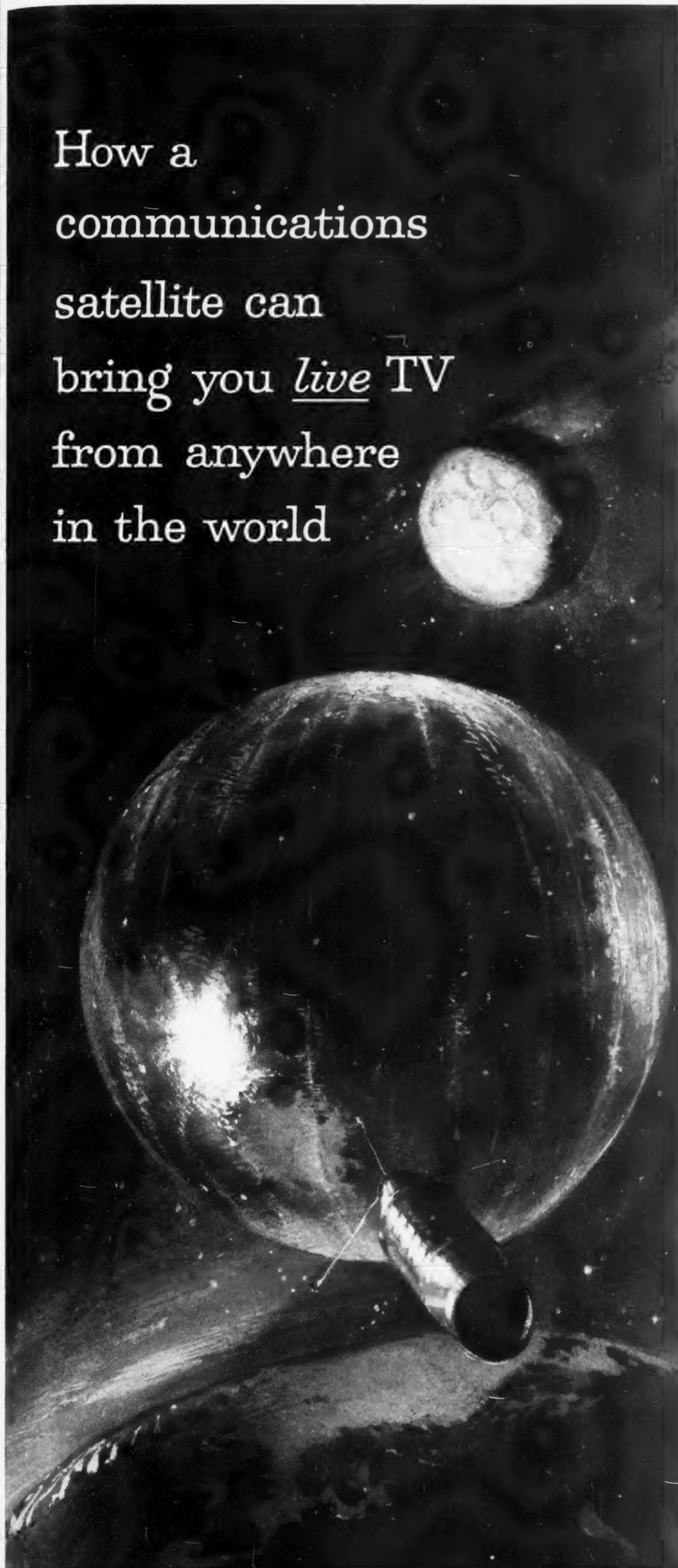
Q: Can it be proved experimentally that the satellites of Mars are of artificial origin?

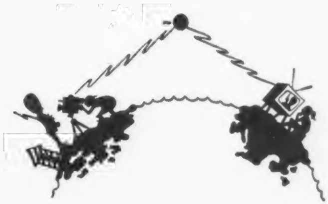
A: Yes, of course it can. The best test will be a direct landing on them by space travelers from earth. But, even according to the boldest forecasts, that will have to wait for more than a decade. Far more realistic is the launching of a rocket probe with scientific instruments to the vicinity of Mars. It could transmit important information about the nature of Mars' satellites in relation to earth.

Ground Observations

Observations from earth can also help in establishing their nature. It is exceedingly important, for example, to make a careful study of the changes in their brightness. It is known, for example, that asteroids, whose size in some cases is 10 times bigger than the size of Mars' satellites, are not round as a rule, for they are simply odd-shaped rock fragments. Their revolution in space around a center of gravity causes pronounced periodic changes in their brightness. If, for example, the brightness of Mars' satellites should prove constant—thus confirming their spherical shape—it would furnish important corroboration of my hypothesis.

One way or another, the hypothesis concerning the artificial origin of Mars' satellites will not remain a hypothesis for long. Within a few years, or a few decades at most, it will either be confirmed by new, absolutely convincing facts, or other explanations will be found to account for the mysterious "pecularities" in the behavior of Mars' satellites. ♦♦





World-wide live TV, with no cable or radio relay costs, can develop from outer-space research by government and industry

Among the peaceful applications for scientific break-throughs being made in the study of outer space is a communications satellite.

Using inflated plastic satellites, boosted toward orbit by the Air Force *Thor* rocket, a global TV network could be established. TV signals would bounce to satellite and back to your station, giving you a front-row seat at events anywhere in the world. Cost should be a fraction of coaxial cables and microwave relays now used.

Practicality of *Thor* for this purpose is based on its demonstrated reliability. With Douglas responsible for airframe fabrication and assembly and test of the entire system, *Thor* has helped launch 84% of all payload weight put into space by the U. S.; is the key booster in the Air Force "Discoverer" firings; launched the first nose cone recovered at ICBM range.

Thor is another product of the imagination, experience and skills which Douglas has gained in nearly 20 years of missile development.

Foil-covered satellite, folded like a pocket raincoat, would balloon out in orbit as an inexpensive TV relay station

DOUGLAS

Builders of the DC-8 Jetliner

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • TRANSPORT AIRCRAFT • AIRCOMB • GROUND SUPPORT EQUIPMENT

Mars-American's Answer

(CONTINUED FROM PAGE 39)

surface of high reflectance. Even if glaciation had been on a limited scale, the island plateaus should have been the sites of large glaciers, but they exhibit no features which could be attributed to sliding ice.

If, by the most optimistic twist of fate, the Martian oceans remained in the liquid state, evaporation would have caused rain and erosion. But the telescope does not reveal the slightest vestige of a dendritic erosional pattern. The remnants of such seas should have become sterile salt beds; instead, the lowest areas are the best vegetated.

In view of such observational evidence, it seems reasonable to conclude that Mars never had much water. The implications are drastic and far-reaching. No sedimentary rocks would have been laid down and consequently no conditions for the formation of coal and oil. That wonderful agent in geology, known as "hydrothermal action," which concentrates many valuable minerals into veins rich enough to make them worth mining, would be inoperative. For instance, ore deposits of manganese (an important ingredient in the manufacture of steel) are concentrated by sedimentation processes. Bauxite, the chief ore of aluminum, is likewise of secondary origin.

Absence of Volcanism

Without superheated steam, there would be scarcely any volcanism and some important minerals resulting from magmatic segregation would also be lacking. Terrestrial volcanoes are known to emit great quantities of water vapor and carbon dioxide. The exceedingly small traces of these gases in the Martian atmosphere attest to the absence of volcanic activity.

It is much too dry on Mars to permit the growth of large woody plants. The major portion of the Martian surface is barren. Without such accessible natural fuels, primitive man would never have learned the uses of fire. Worse still, there is no appreciable amount of free oxygen in the Martian atmosphere to burn the fuels had they existed in the first place. Oxygen is much too active in combining with other elements to remain long in a free state. Free oxygen in a planet's atmosphere can only be sustained by the luxuriant growth of vegetation on the land and by plankton in the seas. One wonders how long our supply of free oxygen will last with the unprecedented combustion of fossil fuels which were slowly accumulated over the ages of time.

Under the adverse conditions on Mars, it is difficult to imagine the existence of luxuriant vegetation. It does appear to cover the ground in the darker maria regions, but it is probably somewhat two-dimensional. The rarefied Martian atmosphere would not provide much scattered light to produce photosynthesis for the underbranches. The vegetation there could hardly amount to more than some glorified equivalent of lichens and mosses. It is, therefore, not surprising to find the Martian atmosphere lacking in free oxygen. Nor does spectral analysis reveal the presence of any other substance which could serve as an oxidizer.

Earth in Contrast

The more we study the characteristics of the moon and the other planets, the more evident it becomes that earth is a most unusual planet, fortunate because of the abundance of water and its remarkable solvent properties, and also because of the favorable temperature which permitted the bulk of it to exist in the liquid state. Just as fortunately, there was not too much water, or there would have been no land surface.

This water is an essential means to the production of abundant food to feed a society of hundreds of millions of individuals, necessary for the creation of a great industrial complex—the very foundation of our present technological civilization. Water has been an essential means to the production of abundant fuel to smelt the ores and drive man's machinery. Indeed, water has concentrated a great many ores of metal to a sufficient degree to be worth mining, including the principal ores of uranium. Indirectly, water is responsible for the free oxygen in our atmosphere, and without oxygen, no combustion engine could run.

Are the Martian satellites so unusual? I think not. In the second "answer" by Dr. Shklovsky, it is asserted that no other planet has such tiny moons. I beg to differ. Three of the outer satellites of Jupiter are of the 19th magnitude, which makes them about 15 miles in diam, very comparable to Phobos.

It is true that Phobos is the only satellite known in the solar system which revolves around its primary in less time than the rotation period of its primary. According to the laws of celestial mechanics, any satellite would do so, whether natural or artificial, if it chanced to be placed at that distance.

The fifth satellite of Jupiter revolves around Jupiter in only 11 hr 57 min, while Jupiter's rotation period is 9 hr 56 min. This relationship is a close parallel to the case of Deimos and Mars.

Also, it is stated that the satellites of Mars lie precisely in the equatorial plane. According to Russell, Dugan, and Stewart, the orbital plane of Phobos is inclined $1^3/_4$ deg, and Deimos 1 deg, to the plane of the Martian equator. Also, "their orbits are nearly, but not quite, circular."

Due to the observed acceleration of Phobos in its orbit, which really is comparatively slight, Fred Whipple has calculated that it would crash on to the Martian surface 60 million years hence, and not 15 million. Dr. Whipple's predictions on the fall of several artificial satellites have been remarkably accurate.

The key argument for Dr. Shklovsky's hypothesis of satellite artificiality is the puzzling acceleration of Phobos. He lists several possible natural mechanisms which would produce acceleration on Phobos, but finds them too feeble to explain the amount of acceleration observed. Therefore he concludes that only an artificial satellite with internal rib work could have a sufficiently low density to be so appreciably affected by the very thin outer Martian atmosphere. There is one other agency that could possibly do the trick which he has not considered.

Dr. Shklovsky states that if an interplanetary resisting medium exists in the vicinity of Mars' orbit, it should affect Deimos as much as Phobos. Hence, he rejects this possibility.

In my article in the January issue of *Astronautics,* I presented arguments which indicate that Mars has been the target of many large asteroid hits, which created the oases-canal systems, and that the angular shapes of the maria were the results of sunken crustal blocks sheared free by these colossal fractures.

Consequences

If this be true, a lot of asteroids cross Mars' orbit. The number of such fragments should increase inversely as the cube of their diameters. If the hits were elastic, no change should ensue because as many would hit a satellite going inside the orbit as coming out. Because of friction and heat generated, there will be a slow loss of orbital kinetic energy and the satellite must gradually fall inward. Owing to the strong gravitational attraction of Mars on asteroids that brush by, they will be deviated toward Mars and hence funneled to a greater concentration in the vicinity of Phobos' orbit than for Deimos.

Phobos would then no longer be required to have a low unnatural density.

◆◆

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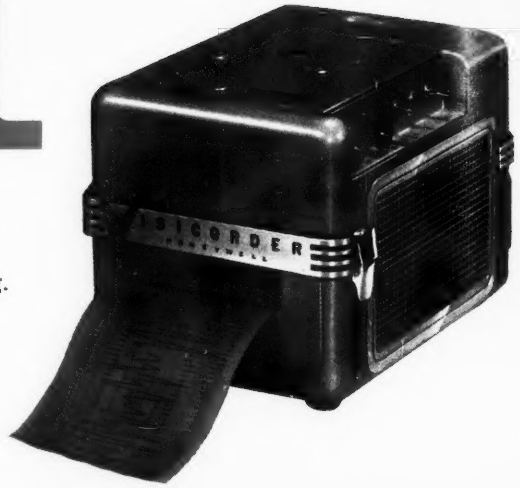
MODEL 1108 24-CHANNEL DIRECT-RECORDING VISICORDER OSCILLOGRAPH

1

MODEL 906 VISICORDER



The original 8-channel Model 906 Visicorder was the first oscillograph to make use of the now-famous Ultra-Violet Visicorder recording principle, pioneered and developed by Honeywell. The 906 Visicorder was the first oscillograph to combine the high frequency response and writing speed of photographic-type oscillographs with the convenience of direct recording. Recent models incorporate time lines and grid lines, and record up to 14 simultaneous channels of data at frequencies from DC to 5000 cycles per second.

The 906 Visicorder is ideal for uses requiring up to 14 channels of data.

3

THE NEW MODEL 1108 VISICORDER OSCILLOGRAPH

Fitting ideally between the 14-channel 906 and the 36-channel 1012, the new 24-channel Model 1108 gives you direct writing Visicorder oscillography at the *lowest cost per channel.*

Like all Visicorders, the Model 1108 was designed from the base up to make the fullest use of the completely proven and unsurpassed Visicorder principle. The new 1108 also directly records at frequencies from DC to 5000 cycles per second at sensitivities comparable to photographic oscillographs. Like the Model 1012, the 1108 incorporates many automatic features and the years-ahead convenience of pushbutton controls.

The Model 1108 Visicorder, the most modern intermediate-size recording oscillograph on the market today, is ideal for intermediate uses requiring up to 24 channels of data.

2

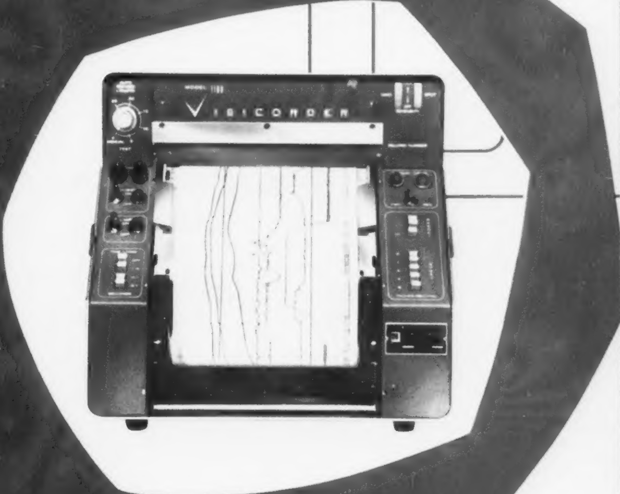
MODEL 1012 VISICORDER

The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for converting as many as 36 simultaneous channels of dynamic data into immediately-readable records. Like other Visicorders, the 1012 permits monitoring the information at the recording point as it goes on the record. It also records at frequencies from DC to 5000 cps.

The Model 1012 Visicorder, with its conveniences and broad capacities, is ideal for large-scale uses where up to 36 channels of data are required.

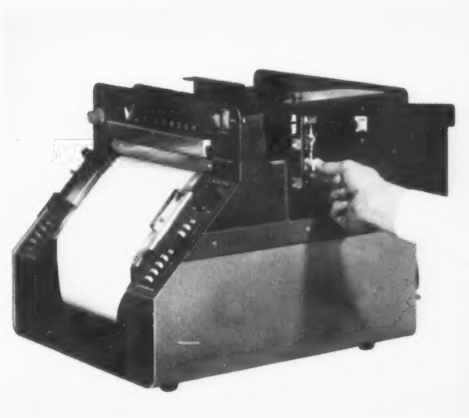
NEW MODEL 1108 VISICORDER provides the ultimate in imme[...] unlimited variety of applications.

The Model 1108 may be used in direct connection with many types of transducers where high frequency recordings are not required. Or it may be teamed with various types of amplifiers where high-frequency—high amplitude readout is desirable. A broad selection of galvanometers with a wide variety of sensitivities and frequencies is available. A schematic diagram designed to suggest sample hookups for various applications—with and without amplification—appears at lower right, and demonstrates the wide variety of uses to which this one recording system may be put.

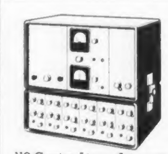


EASY PAPER LOADING . . . *Paper supply assembly swings forward, supply roll drops easily into place. No threading required.*

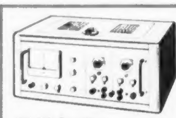
CONVENIENT ACCESS . . . *Covering panels on instru[...] cleaning of optical components, calibrating timer, and to ser[...] REAR VIEW shows rear-panel input connectors.)*



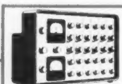
diate, convenient readout of data in an



119 Carrier, Linear/Integrating Amplifier



130-2C Amplifier



82-6 Bridge Balance and Strain Indicator Unit

T6GA—Series Galvanometer Amplifier

INPUT

Resistance strain gauge
Differential transformer
Variable reluctance
Potentiometric
Capacitive
Velocity generator
Electro-kinetic

Resistance strain gauge
Differential transformer
Variable reluctance
Potentiometric
Capacitive

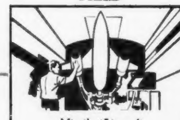
Strain gauge
Potentiometric

DC voltage
AC voltage
Telemetry (fm discriminator) output
Analog computer output

FUNCTION

Stress
Electrical Quantities
Pressure
Nuclear and atomic reaction
Displacement
Mass
Time
Force
Moment
Velocity
Vibration
Harmonic Analysis
Temperature
Light
Chemical phenomena

FIELD

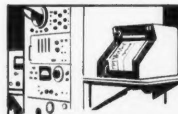


Missile/Aircraft

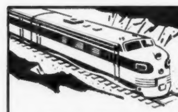
Reactor Analysis

Medical

Telemetry



Production Test



Structural Research

Industrial Test

MODEL 119 *Carrier Amplifier System . . . primarily for resistive, variable reluctance and differential transformer type transducers. Linear and Integrating Amplifiers may replace Carrier units in the case. Frequency response: (Carrier) 0-1000 cps; (linear/integrate) 5-5000 cps. Six channels.*

MODEL 82-6 *Bridge Balance and Strain Indicator Unit . . . controls, calibrates and measures static and dynamic phenomena from resistive transducers. Gives full indication on meter scale with as little as 315 uin/in strain input. Six channels.*

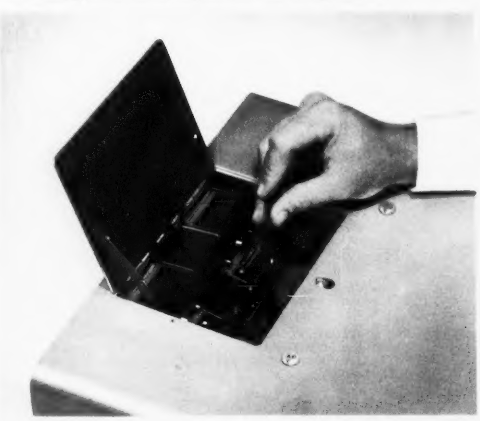
MODEL 130-2C *Amplifier System . . . amplifies output of transducers measuring strain, force, acceleration, flow, pressure, control, displacement, and many other phenomena. Two channels.*

MODEL T6GA *DC Amplifier System . . . a compact 3-stage transistor amplifier which operates the high-frequency Visicorder directly from low power inputs down to 1 volt. Six channels.*

SERIES "M" *Subminiature Galvanometer . . . features minute, sealed construction, higher sensitivity, greater stability. Directly interchangeable in Honeywell Models 1108, 1012, 906A-1, and 906B-1 Visicorders and Models 708C and 712C developing-type oscillographs.*

ment are readily removable for easy access to lamp, vice other assemblies. (THREE-QUARTER

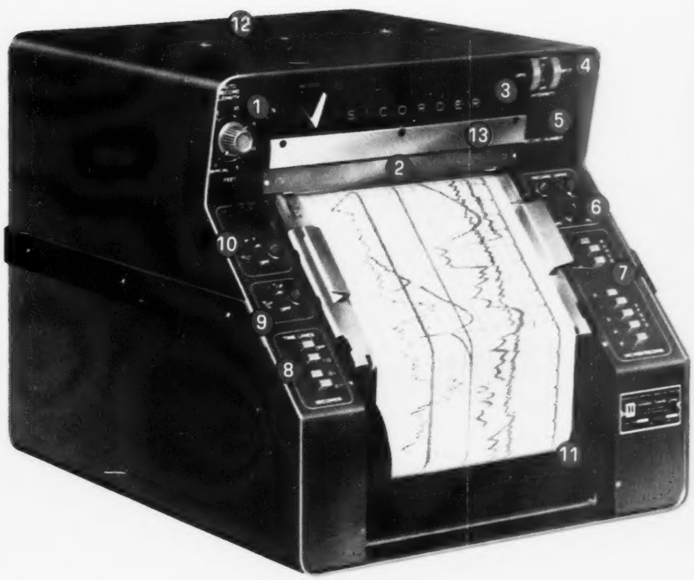
EASY GALVANOMETER ADJUSTMENT . . . *provided through top panel. No clamping or locking is required. Galvanometer spots may be observed at recording point while adjustment is being made.*



MODEL 1108 VISICORDER

adds still more versatility to the Honeywell family of direct recording oscillographs.

Designed to the utmost standards of customer convenience, high-frequency and high sensitivity recording, and reliable, accurate performance, the Model 1108 continues the long-standing tradition of Honeywell leadership through creative engineering. Examine the diagram below for feature-by-feature evidence of this leadership.



3

FEATURES OF THE 1108

General Features

1. **AUTOMATIC RECORD LENGTH CONTROL** . . . *adjustable from 1 to 25 feet . . . indicator shows amount of pre-set record length remaining.*
2. **VISIBLE RECORDING POINT** . . . *galvanometer spots may be monitored through amber screen as they record.*
3. **GRID LINE INTENSITY CONTROL** . . . *manually adjustable to compensate for exposure at various record speeds. (Grid line spacing: 0.1 inch, 5th line accentuated. Custom grid spacings on special order.)*
4. **GALVANOMETER SPOT INTENSITY CONTROL** . . . *off, on, and manually adjustable to control sharpness of galvanometer traces at various record speeds and writing speeds.*
5. **RECORD NUMBERING** . . . *Four-digit resettable record-number counter photographed at start of each record. Flash-tube type; may also be used as event marker.*
6. **RECORD DRIVE CONTROL and INDICATOR** . . . *"Forward" for recording; "reverse" for closer study and analysis of data after recording has been made. Indicator signal light turns off if recording is not taking place.*
7. **RECORD SPEED INDICATOR,** *pushbuttons for 5 speeds plus 3 range pushbuttons give you 15 separate speeds. Speeds may be changed during operation. Positive clutches, no gear meshing.*
8. **TIME LINE SYSTEM** . . . *Electronic flash type, instant warmup. Three selectable intervals: 1, .1, and .01 seconds. No optical parallax. May also be operated from external signal and in multiplex.*
9. **RECORDING LAMP ON-OFF CONTROL AND INDICATOR**
10. **POWER ON-OFF CONTROL AND INDICATOR**
11. **RECORDING PAPER CAPACITY** . . . *8" x 200 feet of standard-weight paper; 350 feet of thin base paper. Take-up integral with record-drive system.*
12. **GALVANOMETERS** . . . *access through top panel. Accepts up to 24 Series M Subminiature galvos, plus 4 static reference galvos. Directly interchangeable among Honeywell Models 906A-1, 906B-1, 1012, 700C oscillographs.*
13. **PAPER KNIFE** . . . *manually operated.*

Other Features

TRACE IDENTIFICATION . . . *at 45° slope, 1/32" width, interrupting galvos in sequence on approximately 8" spacing.*

OPTICAL ARM . . . *11.8 inches (30cm) standard in all Honeywell oscillographs.*

LAMP AND CIRCUIT . . . *High-pressure mercury vapor lamp. Automatic starting.*

REMOTE OPERATION . . . *Control circuits provided for remote operation.*

INPUT POWER . . . *105-130 volts; 60 cycle; 7 amps. 50 and 400 cycle models also available.*

MOUNTING . . . *Table and rack. Shock or vibration mounting using available accessories.*

◀◀◀ open this page

ARS news

ARS Plans Four Conferences in First Four Months of 1960

ARS will open 1960 with four special conferences in four months. The topics for the conferences will be Solid Propellants, Ballistic Missile Defense, Structures and Materials, and Ground Support Equipment.

The first, the Solid Propellants Conference, will be held at Princeton Univ., Jan. 28–29, under the chairmanship of J. Preston Layton, chief jet propulsion engineer, James Forrestal Research Center, Princeton Univ.

The program, compiled by the Solid Rockets Committee under the chairmanship of Ivan Tuhy, will include sessions on Thrust and Vector Control, Unstable Burning, and Grain Design. Also scheduled are sessions on the Interrelation of Nozzle Geometry and Performance; Combustion, Gas Kinetics, and Ignition; and Combustion of Metals.

This will be followed in February by a newly announced, classified conference on Ballistic Missile Defense, to take place in Williamsburg, Va., under sponsorship of ARS and ARPA.

The meeting, to be held February 17–19, will explore topics such as Decoy Detection, Current Ballistic Missile Defense System Development, Range Measurements–Optical and Electrical, and Physics of the Ballistic Missile Defense Problem.

The Ground Support Equipment Conference, organized under the joint sponsorship of the Logistics and Operations and Test Facilities and Support Equipment Technical Committees will be held at the Statler-Hilton Hotel in Detroit, March 23–25. Chairman for the meeting is B. J. Meldrum of Chrysler's Missile Div.

Sessions will cover such topics as Minimum Countdowns, Transporting and Handling Problems, Firing Crews, and Laying, Aiming, Timing, and Tracking.

From April 6–8 at the Santa Barbara Biltmore in Santa Barbara, Calif., the ARS Structures and Materials Committee will hold the Structural Design of Space Vehicles Conference.

The program for this meeting is being completed now under the chairmanship of George A. Hoffman of the Rand Corp. and is expected to cover such topics as Structural Criteria and Design Requirements During Launching, Problems of Re-Entry and Landing on Earth and other Solar System Bodies, and Design of Planned or Existing Vehicles.

Eberhardt Rechtin Appointed *Astronautics* Consulting Editor in Electronics Field

Eberhardt Rechtin, chief of the Guidance Research Division of JPL, has been named Consulting Editor—Electronics for *Astronautics*. In this capacity, Dr. Rechtin, one of the nation's top experts in the fields of space guidance and communications, will help screen articles in these areas for the magazine and insure complete coverage of the entire broad field of space electronics.

Dr. Rechtin joined JPL with a Ph.D. from CalTech some ten years ago. In his association with JPL, he has specialized in range instrumentation, missile radio guidance, information and filter theory, secure communications, and extreme range communications. He has been responsible for direction of much of the JPL effort in space communications and tracking, and, most specifically, the Microlock system for satellites and the TRAC(E) system used on the Army Pioneer for lunar communication.

A Senior Member of the Institute of Radio Engineers, of Sigma XI and Tau Beta Pi, as well as a long-time ARS member, he received the Westinghouse Science Talent Award in 1943, was a Cole Fellow in 1947, and a National Science Fellow in 1948. Dr. Rechtin is particularly interested in international cooperation in space programs, and is chairman of the Avionics Panel of the NATO Advisory Group on Aeronautical Research and Development.

Rechtin

Date Changed in ARS Student Award Competition

Students must submit papers for the 1960 ARS Thiokol and Chrysler student award competition, by July 1, 1960, rather than the previously announced date of Sept. 1. Papers go to ARS Headquarters, 500—5th Ave., New York 36, N.Y., in care of the award being competed for, Thiokol or Chrysler.

1958 IAF Congress Proceedings Offered

Proceedings of the 9th International Astronautical Congress at Amsterdam in 1958 and of the First Colloquium on the Law of Outer Space at the Hague, published by Springer-Verlag, are now available through ARS at a 20 per cent reduction to ARS members. Congress proceedings are offered at \$39.60, compared to the regular price of \$49.50, while the Space Law proceedings are \$3.60, the regular price being \$4.50.

Six More Companies Become ARS Corporate Members

Six more companies have become corporate members of the AMERICAN

On the calendar

1960

Jan. 7, 14, 21, 28	Gas Dynamics Colloquium on Electrostatic Propulson, Shock Tube Research at the Univ. of Michigan, Structure of Strong Normal Shockwaves, and Research in Rarefied Gasdynamics, respectively, Northwestern Univ., Evanston, Ill.
Jan. 11–16	First International Space Science Symposium, and COSPAR Plenary Session, sponsored by COSPAR, Nice, France.
Jan. 12–15	Society of Plastic Engineers' 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago.
Jan. 14–20	6th Annual Meeting of American Astronautical Society, N.Y.C.
Jan. 28–29	**ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.**
Feb. 1–5	ISA Instrument-Automation Conference and Exhibit, Houston Coliseum, Houston, Tex.
Feb. 3–5	IRE Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles.
Feb. 18–19	AIEE Symposium on Engineering Aspects of Magnetohydrodynamics, Univ. of Pennsylvania, Philadelphia.
Feb. 18–20	National Society of Professional Engineers Winter Meeting, Broadview Hotel, Wichita, Kan.
March 9–11	ISA Temperature Measurement Symposium, Deshler Hilton Hotel, Columbus, Ohio.
March 23–25	**ARS Ground Support Equipment Conference, Statler-Hilton Hotel, Detroit.**
April 3–8	ISA Sixth Nuclear Congress, New York, N.Y.
April 6–8	**ARS Structures and Materials Conference, Santa Barbara Biltmore, Santa Barbara, Calif.**
April 6–8	National Meeting of the Institute of Environmental Sciences, Biltmore Hotel, Los Angeles.
April 21–23	AIME Southwest Metals and Minerals Conference on Metals and Minerals for the Space Age, Ambassador Hotel, Los Angeles.
May 2–5	ISA Sixth National Flight-Test Symposium, San Diego, Calif.
May 3–5	IRE-AIEE Western Joint Computer Conference, San Francisco.
May 9–11	ISA Third National Power Instrumentation Symposium, San Francisco.
May 9–12	**ARS Semi-Annual Meeting and Astronautical Exposition, Ambassador Hotel, Los Angeles.**
May 9–13	ISA Instrument-Automation Conference and Exhibit, San Francisco.
May 23–25	**ARS National Telemetering Conference, Miramar Hotel, Santa Monica, Calif.**
June 1–3	ISA Sixth Annual Instrumental Methods of Analysis Symposium, Montreal, Canada.
June 8–11	National Society of Professional Engineers Annual Meeting, Statler Hotel, Boston.
June 15–17	1960 Heat Transfer and Fluid Mechanics Institute, Stanford Univ., Stanford, Calif.
Aug. 15–20	**11th International Astronautical Congress, Stockholm, Sweden.**
Aug. 28–Sept. 1	International Heat Transfer Conference sponsored jointly by ASME, AICE, and Institution of Mechanical Engineers and Institution of Chemical Engineers, both of Great Britain, Univ. of Colorado, Boulder.
Aug. 31–Sept. 7	10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.
Sept. 26–30	ISA Instrument-Automation Conference and Exhibit and 15th Annual Meeting, New York Coliseum, New York City.
Oct. 20–21	Hypervelocity Projection Techniques Conference, Univ. of Denver, Colorado.
Dec. 5–8	**ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.**

Rocket Society. The companies, their areas of activity, and those named to represent them in Society activities are:

Arnoux Corporation, Los Angeles, manufacturer of electronic instrumentation equipment for research and development of rocket powerplants and complete missile assemblies. Named to represent the company in ARS are Richard W. Hodgson, president; Kenneth R. Eldredge, assistant to the president; Michael Dodak, director of marketing; Donald J. Gimpel, director of engineering; and William Drees, chief of quality control.

Collins Radio Co., Dallas, Tex., engaged in communications, guidance and navigation, instrumentation and control, missiles and space vehicles. Representing the company in Society activities are J. E. Froehlich, vice-president, special projects; R. J. Pierce, assistant to director of engineering; J. C. McElroy, director of engineering, Cedar Rapids, Iowa; F. E. Brooks, director of engineering, Richardson, Tex.; and M. L. Doelz, vice-president, Western Div.

Edgerton, Germeshausen & Grier, Inc., Boston, Mass., engaged in instrumentation and services for static and flight-testing in nuclear and advanced propulsion systems. Named to represent the company in ARS activities are Bryant L. Hanson, senior engineer, North Las Vegas, Nev.; Victor M. Tyler, senior engineer, Concord; Daniel F. Seacord Jr., scientific executive, Medway; Percival T. Gates Jr., senior engineer, Weston; and Roy W. Gustafson, engineering assistant, South Weymouth.

Lear, Inc., Santa Monica, Calif., produces automatic flight control equipment, stable platforms, rocket valves, servo-actuators, and miscellaneous instrumentation equipment. Named to represent the company in ARS are A. G. Handschumacher, president; K. Robert Hahn, executive vice-president; J. P. Brown, vice-president, manager, Astronics Div.; L. A. Payne, chief engineer, Astronics Div.; and R. J. Benechhi, group vice-president.

Packard Bell Electronics Corp., Los Angeles, manufacturer of test facilities and support equipment, training aids and communications. Named to represent the company in ARS activities are Richard B. Leng, vice-president in charge, Technical Products Div.; Hugh L. Vick, director, sales and administration, TPD; John A. Rhoads, director of engineering, TPD; Max Palevsky, vice-president, computer; and Donald A. Domike, manager, Aerospace Electronic Support Systems.

United Research Corp. of Menlo

Park, Calif., engaged in research and development of solid-propellant and liquid-propellant rockets. The company will be represented in ARS by Gen. D. L. Putt, president, and vice-presidents B. R. Adelman, D. Altman, H. R. Lawrence, and N. V. Turney.

Proceedings Available

Proceedings of the Sixth Midwestern Conference on Fluid Mechanics and the Fourth Midwestern Conference on Solid Mechanics, held jointly at the Univ. of Texas in Austin, Sept. 9-11, 1959, are now available. ARS was one of the sponsoring organizations for the meeting. Copies of the proceedings are available, at $12.50 per volume, from Engineering Institutes, Division of Extension, Univ. of Texas, 18th and Red River Sts., Austin, Tex.

Meeting Chairman

Tom B. Carvey, manager of the Launchers and Powerplants Dept. of Hughes Aircraft Co.'s Guided Missile Laboratories in Culver City, Calif., has been named General Chairman of the ARS 1960 Semi-Annual Meeting, to be held in Los Angeles May 9-12.

N.Y. Area Student Chapters Plan Joint Activities

Five ARS Student Chapters in the New York-New Jersey area have formed a council to plan joint field trips and lectures. The participating Chapters are from Polytechnic Institute of Brooklyn, Newark College of Engineering, New York Univ., Fairleigh Dickinson Univ. and the Academy of Aeronautics.

Through the council, a joint field trip to the IBM plant in Kingston, N.Y., was arranged for members of the Chapters involved, and IBM generously supplied transportation and lunch for the group, and arranged an excellent plant tour. Additional joint tours and lectures are planned for the coming year.

Longest record of reliability

General Purpose Wirewound Trimpot—Model 200. Operates at 105°C / L,S,P terminals / 1/4 watt / 10 ohms to 100K. Available as rheostat, Model 201.

High-Resistance Wirewound Hi-R® Trimpot—Model 207. Operates at 175°C / L terminal / 2 watts / 100 ohms to 100K. Available as rheostat, Model 208 Hi-R Trim R®.

Dual-Element Wirewound Twinpot®—Model 209. Operates at 105°C / L terminal / 1/4 watt / 10 ohms to 20K. Two potentiometer outputs with one adjustment shaft.

General-Purpose Carbon Trimpot—Model 215. Operates at 125°C / L,S,P terminals / 1/4 watt / 20K to 1 Meg. Available as Mil-Spec humidity-proof unit, Model 235 (1K to 10 Meg).

Subminiature Wirewound Trimpot—Model 220. Operates at 175°C / L & W terminals / 1 watt / 100 ohms to 20K. Meets Mil-Specs for humidity.

High-Temperature, Humidity-Proof Wirewound Trimpot—Model 224. Operates at 175°C / L,S,P terminals / 1 watt / 100 ohms to 100K. Meets Mil-Specs for humidity.

Humidity-Proof Wirewound Trimpot—Model 236. Operates at 135°C / L,S,P terminals / 0.8 watt / 10 ohms to 100K. Meets Mil-Specs for humidity.

High-Temperature Wirewound Trimpot—Model 260. Operates at 175°C / L,S,P terminals / 1 watt / 10 ohms to 100K.

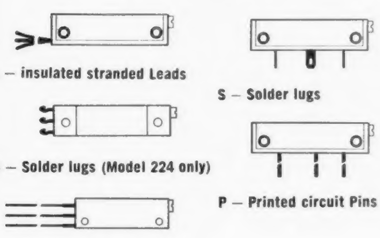
High-Quality Commercial Wirewound Trimit®—Models 271, 273, 275. Operates at 85°C / L,S,P terminals / 1/4 watt / 100 ohms to 10K.

High-Quality Commercial Carbon Trimit—Models 272, 274, 276. Operates at 85°C / L,S,P terminals / 0.2 watt / 20K to 1 Meg.

Panel-Mount Trimpot

All models are now available with the added convenience of panel mounting. Unique design permits quick factory attachment of rugged panel-mount assembly to standard "on-the-shelf" Trimpot potentiometers. The Panel Mount Trimpot takes as little as 1/12 sq. inch of panel space, meets Mil-Specs for vibration, shock, salt spray, etc. Recessed head prevents accidental changes of setting. Silicon rubber O-ring and Teflon washer provide moisture barrier.

Key to terminals



L – insulated stranded Leads

S – Solder lugs

S – Solder lugs (Model 224 only)

P – Printed circuit Pins

W – uninsulated Wires

Standard resistances (ohms)

10	50	200	1K	5K	20K	100K	500K
20	100	500	2K	10K	50K	200K	1Meg

other Resistances Available

Write for detailed specifications and list of stocking distributors.

BOURNS Inc.

P.O. Box 2112P, Riverside, California
Plants: Riverside, California
and Ames, Iowa

In Canada: Douglas Randall (Canada), Ltd., licensee

Exclusive manufacturers of TRIMPOT®, TRIMIT®. Pioneers in potentiometer transducers for position, pressure and acceleration.

Other Student Chapters desirous of participating in the program may obtain information from any of the Chapters which are now members of the council.

1960 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
Jan. 28–29	Solid Propellants Conference	Princeton Univ.	Past
March 23–25	Ground Support Equipment Conference	Detroit, Mich.	Past
April 6–8	Structures and Materials Conference	Santa Barbara, Calif.	Dec. 15
May 9–12	ARS Semi-Annual Meeting and Astronautical Exposition	Los Angeles, Calif.	Jan. 18
May 23–25	National Telemetering Conference	Santa Monica, Calif.	Feb. 1
Aug. 15–20	11th International Astronautical Congress	Stockholm, Sweden	April 15
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Aug. 25

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

SECTIONS

Alabama: The Alabama Section ambitiously opened a new year of activities with a special program designed to inform its members and other interested persons in their community on plans and progress for manned spaceflight, and in particular Project Mercury. The program featured field trips Oct. 3 and 6 to ABMA for tours of Saturn and Jupiter testing facilities. On hand to answer questions during the tours were **Gordon Artley, Karl Heimberg, David Newby, Siegfried Gerathewohl,** and **Joachim Kuettner.** After each trip, the party gathered at the Rocket Auditorium at Redstone Headquarters and heard a talk entitled "Man's Round Trip to Space" by Dr. Kuettner, director of Mercury project work at ABMA. Section vice-president Konrad Dannenberg presided at the evening sessions. David Newby of NASA introduced Dr. Kuettner.

Also, as part of this program, Dr. Gerathewohl spoke at the first annual meeting of the Auburn student chapter of the Society on Oct. 6. He discussed "Zero Gravity in Spaceflight," as he had done for the Alabama Section last year. Rod Stewart, Section president, accompanied Dr. Gerathewohl at the Auburn meeting.

Alabama Section members feel that the response to this unusual program has been good, and will look into the possibility of expanding it in the coming year.

Central Indiana: At a meeting in late September, 95 members heard guest speaker **M. Baron T. George,** director of the Plans and Programs Office of Avco-Wilmington, discuss reentry vehicles, a subject he is eminently qualified to speak on, having had extensive professional experience with the aerodynamic, structural, and materials design of ICBM nose cones.

Dr. George presented and discussed various ways of curtailing aerodynamic heating of ICBM's, satellites, and spaceships; ablation seems to be the most promising approach to the thermal barrier. Remarking on flight paths, he noted that the space pilot would have to set his controls over Australia to land successfully in Indianapolis. He also stated that a spaceship should come in directly rather than lose speed by circling the earth as a satellite. A film and slides illustrated Dr. George's presentation.

—**Marshall Fisher**

Alabama Section Sees Saturn Version Static-Fired

Participants in the Alabama Section's recent Man-in-Space Program saw this quarter-scale version of the Saturn booster static-fired at ABMA. Saturn is now being developed for NASA by the space agency's newly acquired development group headed by Wernher von Braun.

Chicago: At the September dinner meeting, held at the Fifth Army Headquarters Officers Club, the Section was host to ARS President **Col. John P. Stapp.** Over 185 persons attended the banquet and Col. Stapp's illustrated lecture on "Problems of Manned Spaceflight." The capacity audience was shown films on weightlessness tests conducted with aircraft flying predetermined trajectories, and on human centrifuge and rocket-sled acceleration tests.

The main problems to be encountered by the Astronauts are gravitational accelerations, food and water, oxygen, weightlessness, and noise and vibration. Col. Stapp cited the results of various test programs which have determined the optimum body position for withstanding accelerations,

and mentioned that the Russian dog experiments indicate that weightlessness should not impair bodily functions.

—R. C. Warder Jr.

Columbus: At the regular monthly meeting in October, guest speaker **Lovell Lawrence Jr.**, who needs no introduction, discussed the satellite as a celestial navigation instrument and relay point and the design of the Astro system for this purpose. His timely talk was well received.

Early in November, the Section had the pleasure of hearing guest speaker **Merle Smallberg,** manager of special Astro products for Marquardt, discuss hypersonic ramjets and explain theory and test results that suggest that up to Mach 15 flight will be possible with the ramjet.

Later in the month, the women's auxiliary of the Section invited their husbands to join them at the home of Wilbur A. Spraker Jr. for a box dinner and other conviviality.

Detroit: A special field trip and dinner meeting in October gave Section members an extensive look at nuclear science for the Space Age. On the afternoon of Oct. 19, Alfred Amorosi, technical director of Atomic Power Development Associates Inc. of Detroit, led a tour of the Enrico Fermi Reactor in Trenton. This field trip was followed by dinner and a meeting featuring a talk on "Nuclear Reactors in Space" by Francis E. Jablonski, senior nuclear physicist at General Motors. Dr. Jablonski described some of the problems of nuclear propulsion systems, especially those of materials; and he went into the application of nuclear systems to high- and low-thrust vehicles and to auxiliary power supply.

Holloman: The Section has elected the following officers for the coming year: Harold J. von Beckh, president; Lt. Col. Bernard W. Marschner, vice-president; Harry H. Clayton, secretary; and Kenneth M. Haggard, treasurer.

—Lt. Col Harry L. Gephart, USAF

Houston: The theme of the September meeting of the Section was "Ultra-Sonic Inspection." Members learned about the use of sound inspection in the construction of rocket bodies and motors and similar constructions. Also, color films of some recent ICBM firings at Cape Canaveral were shown.

The officers for this new Section are Lawrence Megow, president; Dennis Ashton, vice-president; C. B. Schreiber, treasurer; and J. B. Dancer, secretary.

North Texas: At the September

Welcome Orlando

ARS President Col. John P. Stapp presents charter to the new Orlando Section at a summer meeting. Flanking Col. Stapp, who holds the charter, are, from left, H. C. Sanderson, G. Anderson, R. F. Krauss, D. K. Robertson, A. Chappelle, and G. Gaspard.

What Problems, Progress on Manned Spaceflight?

This was the theme of ARS President Col. John P. Stapp's address to the Chicago Section recently. Above, standing, Col. T. V. Ryan, USA, of 5th Army Headquarters special projects office, and C. C. Miesse, president of the Chicago section, welcome Col. Stapp. Seated, from left, R. F. Gartner, J. F. Elward, M. Goldstein, Col. Stapp, Elliot Raisen, Father Donald Roll, and Henry Coleman.

Mars Trip Talk

North Texas Section members, from left, Harry Graham, Ron Krape, Jim Haden, and Jack Kerr, question guest speaker Lt. Col. Lee B. James, USA, of ABMA on some of the fine points of a trip to Mars, which he discussed at the Section's September dinner meeting.

dinner meeting, attended by some 200 members and guests, guest speaker **Lt. Col Lee B. James,** USA, chief of the ABMA Control Office R&D branch, discussed propulsion, guidance, and survival problems in a spaceflight to Mars. Col. James also showed two movies, one on spaceflight experiments with monkeys and the other on Jupiter nose cone recovery.

—W. H. Bender

Orlando: This new Section received its charter in a summer dinner meeting, with honored guest **Col. John P. Stapp,** USAF, ARS president, making the presentation. Later in the evening, Col. Stapp discussed plans and progress toward manned spaceflight.

The new officers of the Section are James Q. Brantley, president; Roland Martinusen, vice-president; R. F. Krauss, treasurer; and William E. Krauss, secretary.

The October dinner meeting featured a talk by guest **W. F. Hilton,** head of the Aeronautics Department of Armstrong-Whitworth Aircraft, Ltd., of England, on "The Flying Pyramid," a re-entry vehicle design that looks halfway between a glider and a blunt nose cone.

Princeton: The roar of ascending rockets reverberated through Room 46 of Princeton's McCosh Hall at the October meeting as guest speaker **Charles W. Williams,** director of manufacturing operations for Chrysler's advanced projects organization, discussed highlights of Redstone and Jupiter launchings at Cape Canaveral.

This meeting is the first to be sponsored by the newly formed Princeton Section, which branched out this fall from the New York Section. Officers of the new Section are Jerry Grey, president; Sidney Sternberg, vice-president; and Arnold Goldburg, secretary-treasurer.

—Jerry Grey

Sacramento: At the September dinner meeting, held in the Sacramento Inn, an amusing but thought-provoking hoax was perpetrated on the Section. The program chairman announced that **Robert Truax,** the expected speaker, had suddenly been called to Washington and would not be able to appear. **Professor Vladimir Suvokoff,** an acquaintance of Richard Geckler, who recently toured Russia and reported his impressions to the Section, would honor the membership with a brief talk in his stead. This gentleman proceeded to harangue those present on ridiculous security and technical aspects of the American missile and space programs, and the contrasting wonder of things in the U.S.S.R. He can be seen in action in photo below. Well, then Bob Truax took off his beard and gave a brief talk about how early work in American rocket development contrasted with some current practice.

At the October dinner meeting, held in the Coral Reef Restaurant in Sacramento, guest speaker **A. L. Antonio,** vice-president of Aerojet's Chemical Div., discussed "Capital Risks in Defense Industries," with emphasis on the economic life of a chemical investment in strictly defense work.

St. Joseph Valley: The October meeting was held in the Engineering Auditorium of the Univ. of Notre Dame. Approximately 75 members and guests heard guest speaker **Bryce Wilhite,** assistant general manager and technical director of Thiokol's Utah Div., discuss "The Future of Solid Propellant Rocketry." In exploring this subject, he made this point: "I

"Professor Suvokoff" Explains Soviets' Lead

It's really Bob Truax telling the Sacramento Section that he hopes the moss on his chin will not also get pinned on the U.S. space program; see Section News for more details.

am *not* here to defend or reiterate the feasibility of solid-propellant units as primary or secondary sources of propulsion . . . this has been done by demonstration." His statement was based in part on the recently successful test of a Minuteman missile with live first-stage engine fired from a silo underground-launching facility in California. A Minuteman first stage is being developed by the Utah Div.

Referring to major problems of rocket engine logistics—the moving of the larger engines to distant launch sites over existing road or rail networks —he suggested alternatives: Air transportation or near-manufacturing-site launching. Possibility of the latter was proved in the recent silo-launch of Minuteman.

—Marvin S. Ehrenberg

Wichita: Some 40 members and guests attended the regular monthly meeting in October. Following dinner at Albert's Restaurant, the party was conducted on a tour of the production line of the KDB-1 missile target at Beech Aircraft Corp., and then viewed a color movie of the testing of this drone at Point Mugu. **R. Harvey Anselm** gave a very interesting briefing on the KDB-1 before the tour.

—Dean E. Burleigh

USN Postgraduate School Chapter Receives Charter

Lt. Cameron G. McIntyre, RCN, president of the new ARS Chapter, looks over charter presented by ARS Director A. J. Eggers Jr. (right) at a recent installation meeting in Monterey, Calif., home of the Postgraduate School.

And Welcome Neosho

ARS President Col. John P. Stapp, right, presents the new Neosho Section's charter to its president, W. J. Baisley, in banquet ceremonies Oct. 23 at the Empire Room of the Conner Hotel in Joplin, Mo. Col. Stapp later spoke to the assembled Section members and guests on problems of manned spaceflight. Other Sections officers are R. J. Collins, vice-president; L. W. Lutz, secretary; and R. H. Jensen, treasurer.

STUDENT CHAPTERS

City College of New York: The Chapter received its charter at a special meeting in October. The charter was presented by **Richard Frazee,** president of the New York Section, who was also the principal speaker.

The officers for the new Chapter are Alvin Brent Blacksburg, president; Laurence Heidelberg, vice-president; Frank Pinter, treasurer; and Ira Skurnick, secretary. Seymour L. Zeiberg is the faculty adviser.

In a November meeting, the Chapter had the pleasure of hearing guest speaker **Abraham Hyatt** of NASA describe and explain the space vehicles planned by the national space agency.

Parks College: Chapter officers recently elected are as follows: Stephen J. Koob, president; Curtis M. Campbell, vice-president; Barry B. Flachsbart, technical activities chairman; Ralph J. Gerke, secretary; Gilbert F. Kelley, corresponding secretary; Mohammed Ahmed, treasurer; and Stephen J. Colaprete, librarian.

—Ralph J. Gerke

Univ. of Florida: Chapter officers recently elected are as follows: Jack Bodne, president; Charles Zaffery, vice-president; Robert Goodmark, recording secretary; Antonio Garcia, corresponding secretary; and Perry Melvin, treasurer. David T. Williams is the Chapter's faculty adviser.

—Antonio Garcia

Univ. of Miami: At a meeting early this fall, the following officers were elected to serve during the coming year: John E. Colbert Jr., president; Phil Napoli, vice-president; Alan S. Victor, secretary; and Don Von Haber, treasurer. The Chapter's faculty adviser is Boyd B. Oellerich.

Univ. of Michigan: The Chapter held its first meeting October 6. Members enjoyed a movie on space travel. Officers for this year, elected last spring, are Raymond W. Waugh, acting president; Edwin Hammer, treasurer; Arthur Charmatz, recording secretary; and Judith M. Forde, corresponding secretary. Dr. Morrison is the new faculty adviser, as Prof. Rogers is now on leave of absence. One of the activities proposed for the coming year is a field trip to Chrysler Missile Div.

High spots of last year included a lecture on nuclear rockets by Prof. Pidd of the Physics Dept. This spring saw the inauguration of Engineer's Weekend, which was held May 7-9. The various engineering depts., the student technical societies, and invited industrial firms all had exhibits around the engineering campus. Also included were lectures and an open house on North Campus. For this, the chapter had charge of the aeronautical and jet propulsion laboratories. A short film on high-altitude research vehicle firings was shown, and various pieces of lab equipment were displayed and demonstrated.

—Judith M. Forde

CCNY Student Chapter Chartered

Alvin B. Blacksburg, center, president of the new College of the City of New York Student Chapter, accepts charter from New York Section President Richard Frazee, at left. Geoffrey A. Potter, ARS membership manager, watches the ceremony, which took place Oct. 8 at CCNY. The other new officers of the Chapter are Laurence Heidelberg, vice-president; Frank Pinter, treasurer; and Ira Skurnick, secretary.

ASTRO Covers Available

In response to a number of requests, *Astronautics* is offering full-color reprints of its covers.

These reprints will be in the form of laminated plastic display plaques, with a metal D-ring on the back for easy mounting on a wall. The full-size cover, with a suitable mat, is mounted on 1/4-in. rigid hardboard, with beveled edges, and over-laminated with transparent vinyl plastic. Size of the plaque is 11 by 12 in. Cost is $2.00, and only a ***limited supply*** of covers will be available each month.

The plaques may be obtained by writing to *Astronautics,* 500 Fifth Ave., New York 36, N.Y.

U.S. Naval Postgraduate School: In September, the Chapter received its charter, the presentation being made by **A. J. Eggers Jr.** of the Northern California Section, and installed officers, who are: Lt. C. G. McIntyre, RCN, president; Lt. R. L. Enos, USN, vice-president; Lt. M. C. Farren, USN, secretary; and Lt. C. J. Rorie, USN, treasurer. Lt. McIntyre is one of several Canadian officers attending the Postgraduate School who are ARS members. To round out a constructive and pleasant evening, Dr. Eggers discussed the ARS and then reviewed NASA and a number of its projects, illustrating several with movies.

—Robert L. Dise, LCDR, USN

CORPORATE MEMBERS

Acoustica Associates is negotiating the acquisition of Ender Monarch Corp. of Garfield, N. J., prominent in illumination engineering . . . **Air Products Inc.** has opened an office in Orlando, Fla . . . New construction totaling 50,000 sq ft is now in progress at **Atlantic Research Corp.**'s headquarters . . . **Chance Vought Aircraft,** through stock purchases, has acquired majority interest in National Data Processing Corp., Dallas, Tex. . . . A propellant research laboratory, an engineering building, and a new administration building are major items in **Grand Central Rocket Co.**'s upcoming multimillion dollar expansion program . . . **Linde Co.** recently dedicated a new multimillion dollar plant, with a combined capacity of nearly 300 tons daily of liquid oxygen, nitrogen, and oxygen at Pittsburg, Calif. . . .**Arthur D. Little, Inc.,** has opened an office in Zurich, Switzerland.

North American Aviation completed purchase of full interest in Astrodyne and its merger into NAA . . . **Raytheon**'s storage Tube Dept. has been transferred to the company's Industrial Tube Div. . . . **Republic Aviation** set up an Economic Research and Corporate Planning Div. to serve as an evaluation group . . . **Servomechanisms, Inc.,** announced formation of "Mechatrol of California" (manufacturer of precision instrument motors and accessories used in aircraft and missile control equipment) as liaison for West Coast customers of SMI's Mechatrol Div. . . . **Sylvania Electric Products, Inc.,** has integrated the newly formed systems Engineering and Equipment Engineering laboratories into its Electronic Defense Laboratories, Mountain View, Calif. . . . And **Telecomputing** has integrated its two electronic divisions, Brubaker Electronics and Nuclear Instruments, into a single unit, Electronic Systems Div. at North Hollywood, Calif. The company also announced recent purchase of Monrovia Aviation Corp., a wholly owned subsidiary of Carrier Corp. and manufacturer of aircraft subassemblies and ground support equipment. Purchase price was estimated in excess of $2 million.

COMMITTEES

Education: Irvin Michelson, head of the Aeronautical Engineering Dept. at Penn State, has been named vice-chairman of the ARS Education Committee, while N. Elliott Felt Jr. of Martin-Baltimore; Hubert E. Coyer of Convair-Astronautics, Edwards AFB; Stanley Mosier, of Pratt & Whitney, W. Palm Beach, Fla.; and John Boretz, Martin-Denver have been named to the committee.

Responsibilities of the committee have been divided among a number of panels. Already in operation are panels on incentives, meeting programs, educational methods, publications, and curricula.

Memorial Fund

An education fund for the children of the late pioneer balloonist M. Lee Lewis has been set up by General Mills, Raven Industries, and G. T. Schjeldahl Co. Mr. Lewis, who made the first plastic balloon flight to the stratosphere with Navy Commander Malcolm D. Ross, was killed last July 6. He is survived by his wife and four children.

Spacecraft Power

(CONTINUED FROM PAGE 37)

available from the stoichiometric reaction produces an impulse of approximately 350 sec (pressure ratio 20:1) and a temperature of approximately 5500 F. This is obviously too high for any turbine. The temperature can be reduced by adding excess fuel or oxidizer.

However, if one chooses to depress the temperature by adding excess hydrogen, the impulse does not go down immediately, but rather goes up to a peak of 380 sec, which is obtained with a gas temperature of approximately 4000 F. This temperature is still too high for a prime mover to run for a long time. A temperature of about 1800 F is considered desirable for such a machine. This can be obtained by running at still higher percentages of hydrogen. Now the impulse drops off, but the adding of the low-molecular-weight hydrogen balances the heat-drop in part, so that at a temperature of 1800 F there is obtained an impulse of about 340 sec, or about twice that available even from the hydrazine. For this reason, and others which will be discussed, the oxygen-hydrogen system is extremely attractive for power generation.

Inasmuch as these power systems will be operating at very low pressure ambients, it is possible to consider very high-pressure ratios for expansion without going to unduly high gas-generator pressures. Energies available from the propellant systems under consideration are shown in the first table below.

Engine Efficiency

In comparing these systems, it is necessary to consider the probable efficiency of energy conversion into shaft work in a prime mover. Consider the graph on page 74, which shows actual performance of an existing two-stage axial-flow turbine operating on hydrazine (Curve B) and oxygen-hydrogen (Curve A) combustion products at 1800 F and a pressure ratio of 150:1 at 25 hp output. The power output on which this performance is based is power out of the gear box available to drive a generator or other accessory at 12,000 rpm. In addition, Curve C of the graph shows the estimated performance if the same machine operated on 98 per cent hydrogen peroxide. The approximate engine efficiency of this turbine at the 30-hp point ranges from 30 per cent for oxygen-hydrogen to 55 per cent for hydrazine and 60 per cent for hydrogen peroxide. This shows increasing specific fuel consumption with increasing efficiency, and helps to illustrate the fact that *engine efficiency by itself is not an adequate measure of performance for auxiliary power systems.*

Several turbine design programs are currently in progress at Walter Kidde. Within the next six to nine months, these programs are expected to show a 10 to 20 per cent reduction in specific fuel consumption below that shown by the curves of the graph on page 74. It is reasonable to assume that improvements can be achieved beyond even this performance.

The graph on page 74 illustrates performance which should be realized within the next few years, provided some serious effort is made in this direction. For example, the hydrogen-oxygen system will probably reach its peak performance with a turbine incorporating four to six pressure stages. The development and refinement to practice of such a machine requires an appreciable program as measured both in time and dollars.

Other Factors

Besides specific fuel consumption, there are other factors which enter into the choice of propellant system for a particular vehicle. Perhaps the most important supplementary function which can be served by a particular fuel system is that of providing a heat sink. In a space vehicle, propellant energy not dumped overboard as exhaust products ultimately appears as heat load somewhere in the vehicle. As dissipation of this heat into space by radiation can be prohibitive in terms of equipment weight at the temperature levels involved, a sink in the vehicle is extremely desirable. Propellants for a secondary power system can provide a portion of the required heat sink, since they can undergo a temperature rise before burning.

The last table at left shows heat-sink capabilities of the propellants under discussion and also gives the weight of a supplementary coolant that provides a total heat-sink capability equal to the useful energy provided by each pound of propellant.

It is obvious that an effective propellant heat sink would call for an early consideration of its cooling functions by the vehicle designer. The equipment cooling circuits, heat exchangers, and so forth would need to be appropriately laid out in the initial vehicle-configuration studies. The diagram on page 37 of a hydrogen-oxygen propellant system integrated with cooling equipment for a space vehicle illustrates the intimate interrelationship of the two functions.

The second table at left gives the weight of fuel, coolant, and tankage required to generate each horsepower-hour of useful shaft energy and at the same time to provide a heat sink capable of absorbing all energy dissi-

Available Energy (Isentropic Expansion) in Btu/lb

Fuel	Pressure Ratios 10:1	100:1
100% hydrogen peroxide	360	580
96% hydrazine	540	900
50% oxygen-50% hydrogen	2000	3100

* 40% ammonia dissociation

System Ratings (lb/hp-hr) with Coolant

	Fuel	Coolant	Tankage	Total
96% Hydrazine	3.5	2.1	0.2	5.8
100% Hydrogen peroxide	5.8	2.0	0.2	8.0
50% Hydrogen-oxygen	1.4	1.3	0.7	3.4

Propellants as Heat Sinks

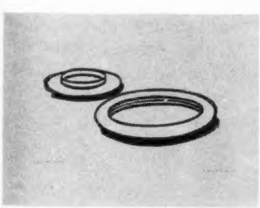
	Hydrogen	96% Hydrazine	100% H_2O_2	50% O_2–H_2*
Min. storage temp., F	−405	40	40	—
Max. temp. into gas generator, F	200	200	200	—
Heat absorbed, Btu/lb	1800	120	100	900
Useful power, Btu/lb**	—	730	440	1820
Supplementary coolant lb water/lb propellant	—	0.61	0.34	0.92

* Data covers only the heat-sink capacity of the hydrogen component.
** Based upon 30-hp point of predicted turbine performance given in graph on page 74.

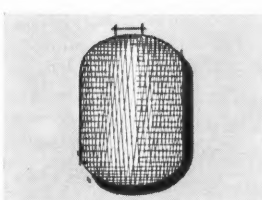
You'll like Garlock's habit of being on time...

At Garlock, delivery of high quality rocket motor components in the shortest time is of prime importance. To meet this objective, research and development, product design, tool design, pilot manufacturing, and production staffs work together as a fully integrated team. By solving problems of design and production jointly, they avoid time-consuming redesigning and retooling.

Flexible, Diversified . . . Garlock will swing into prototype production on short notice and follow this with full scale production as needed . . . will design and manufacture rocket motor components from a variety of basic materials—rubber, metals, phenolics, fluorocarbon plastics.



FILAMENT WOUND ROCKET MOTOR cases made by exclusive Garlock method result in structure much lighter and stronger than steel.



INSULATION for solid fuel rocket motors made by Garlock is rubber-like compound which encounters gas velocities of Mach 3-5, temperatures to 5500°F, prolonged ambient temperatures of 300°F.

MISSILE PARTS from inert materials including newly developed asbestos-phenolic compound for nozzles . . . nose cones of fluorocarbon plastics.

GARLOCK METAL FITTINGS for rocket motor cases such as blast tube and thrust terminator support rings are machined to extreme tolerances. Materials afford minimum weight, maximum strength and rigidity.

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Garlock components are presently used in the development and production of:

- Vanguard
- Super Vanguard
- Polaris
- Terrier
- Minuteman
- Nike Hercules
- Super Tarter

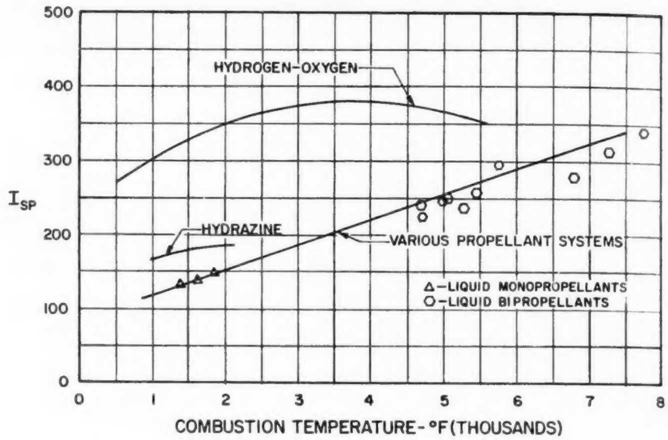
pated as heat. The coolant requirements are calculated on the basis of the propellant heat-sink capacity and the corresponding supplementary water requirements (h_{fg} = 1000 Btu/lb.) as given in the table on page 72.

This analysis also assumes the following:

1. Heat-exchanger weight is a function of vehicle heat load and is independent of the propellants selected.
2. The energy-conversion equipment—gas generator, turbine, gear box, controls, etc—will not be significantly different in weight for the three propellant systems cited. This equipment would weigh less than 200 lb.
3. Propellant feed in the hydrazine and hydrogen peroxide systems is by means of engine-driven fuel pump. Storage tanks are pressurized only to a nominal value of 50 psi to feed into the fuel pump.
4. The bipropellant system is a straight pressure feed from liquid storage tanks pressurized to approximately 400 psi by controlled heat input.

This weight analysis shows that a properly designed oxygen-hydrogen system could generate electrical power, with complete cooling, for a total installed system weight of 5.1 lb/kw-hr and, without cooling, for only 3.2 lb/kw-hr. Furthermore a system could readily be designed to provide power output at almost any desired rate without impairment of these performance figures.

Specific Impulse of Propellant Systems

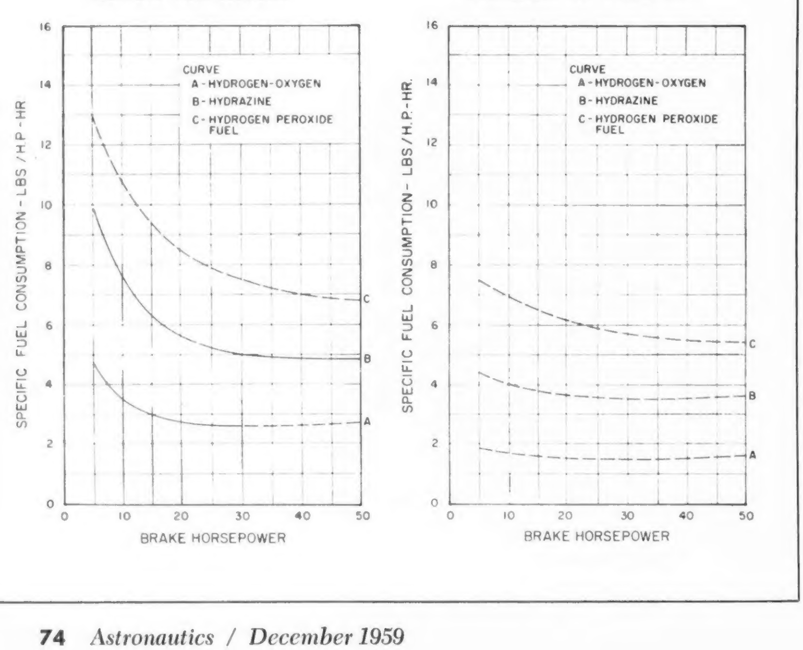


Besides generating electrical or hydraulic power, the propellant systems cited can also directly actuate controls. For example, the discharge of propellant gases through small thrust nozzles can provide reaction forces for vehicle attitude control or maneuvering. Also, the propellant gases can be metered through servovalves to mechanical actuators to form a hot-gas servosystem. All three of the propellant systems described are well suited for these functions. At the present time, hydrogen peroxide is widely used in reaction control nozzles, principally because initiating its decomposition is easy.

With respect to the use of hydrogen peroxide, another interesting concept arises in the case of a vehicle delivering supplies from the earth to a space laboratory. If part of the useful cargo of this vehicle were oxygen and water in appreciable quantities, the decomposition products of the hydrogen peroxide could be considered useful load if they could be recovered. Then the only fuel-weight penalty for the secondary power system with respect to the outbound voyage would be the weight of equipment required for recovery of the exhaust products, plus, of course, the tankage and coolant penalties. At the present time the weight penalty for the recovery equipment appears to be prohibitive, but improvements are no doubt achievable.

Performance of Two-Stage Axial-Flow Turbines

Current Test Results | **Predicted for 1962–65**



State of the Art

The state of the art for each of the systems under discussion is not at a comparable level at the present time. With respect to long-running secondary power systems, hydrazine appears to have the most background (based upon operation of individual units for periods in excess of 50 hr and accumulation of hundreds of hours of total running time experience on a group of units), with hydrogen peroxide second and hydrogen-oxygen last.

Hydrazine equipment is substantially proved, and this same statement can be made with respect to hydrogen-

peroxide equipment, except that the analyses here are based on 98 and 100 per cent peroxide, whereas most experience to date has been with 90 per cent peroxide. As the higher concentration peroxide appears to have every bit as good or better storage stability as the 90 per cent peroxide, handling should be no more of a problem, and the only area for investigation and verification of performance for long periods of time would appear to be in connection with the decomposition chamber. The higher temperatures associated with the more concentrated peroxide require further development of decomposition chambers for long-running systems.

With respect to the hydrogen-oxygen system, the gas generators and turbines have been operated on a basis completely consistent with the performance and the requirments described here, but extensive experience has not been accumulated. Probably the most complex development problem lies in the area of integration with the vehicle system and development of containers, heat exchangers, and controls which will be compatible with the dual requirements of the heat-sink and power-generation functions.

Some Advances Made

In general, however, the art with respect to the chemically fueled open-cycle powerplant has achieved a modest degree of maturity. Much of the data presented here has a background of 10 years of development work and hundreds of actual running hours to support it.

Moreover, the basic designs of much of the mechanical energy conversion equipment do not change radically in going to a new fuel system, such as oxygen and hydrogen. Therefore, the curves in this article showing present and predicted performances can be used with confidence, and should enable designers to arrive at estimates which are entirely adequate for preliminary design and planning purposes.

Finally, it would be highly desirable to present similar data for closed-loop powerplants so that concrete comparisons and evaluations could be made for specific applications under consideration. The art with respect to the closed-loop plants, however, is much less mature, and really comparable data does not exist. The writer's firm, along with others in this field, are working hard to remedy this situation, and it is hoped that we will be able to present similar data in the not-too-distant future. ♦♦

Ringing in the Future

(CONTINUED FROM PAGE 30)

Lab and ABMA engineers. It will power the 20-mc transmitter for about a year, and then will be shut off by a miniature timer, shown below right, to clear the radio frequency band for other use. This is in accord with recently established policy on space communications.

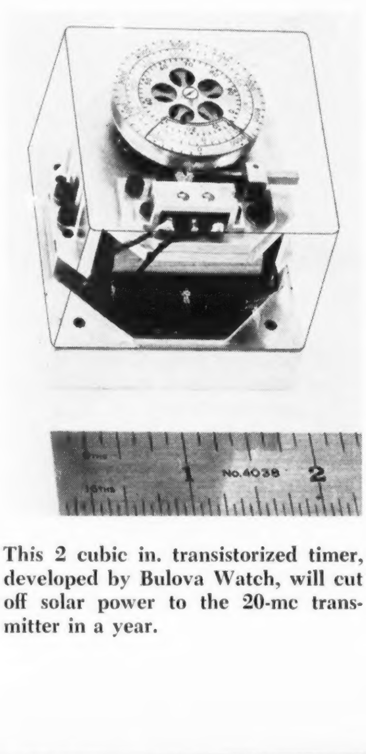
Explorer VII was launched in a northeasterly direction into an elliptical orbit of 680-mile apogee and 346-mile perigee that will sweep to 50-deg N and S latitudes, or over most of the land area of the earth. This orbit was very nearly the one planned to bring the satellite into good position to make earth radiation balance measurements. It is a stable orbit, giving the satellite an expected life of some 20 years.

The ABMA group's skill in space-vehicle launching showed brilliantly with Explorer VII. Liftoff was scheduled for 10:30 a.m. EST and came 0.4 sec later. Thrust cutoff of the Jupiter booster was controlled to within 1.91 sec. No deviation of third- and fourth-stage ignitions from the planned times could be detected. The total velocity error was 59 fps.

Seven Experiments

The same evidence of technical skill is expected from Explorer VII's seven experiments, which are as follows:

Radiation balance experiment, proposed by Harry Wexler of the U.S. Weather Bureau and conducted by Verner E. Suomi of the Univ. of Wisconsin. Radiation balance is nearly constant over the entire earth for a period of several years. However, the planet receives more energy from the sun near the equator than it radiates into space; and it radiates more energy into space from the poles than it receives from the sun. Thus, energy must be tranferred from lower to higher latitudes by ocean currents and the atmosphere. This transfer will be studied by measuring (1) direct radiation from the sun, (2) the fraction of this radiation converted into heat by the earth, clouds, and atmosphere, and (3) the fraction of radiation converted into heat by the earth and ultimately re-radiated back into space in the far-infrared portion of the spectrum. The six sensing elements designed to measure these quantities are (1) two small hemispheres painted black to measure total energy at all wavelengths, (2) two hemispheres painted white to measure radiation in the longer wave lengths while reflecting short wavelengths, and (3) two Tabor sensors, which have a coating sensitive to shortwave radiation only.



This 2 cubic in. transistorized timer, developed by Bulova Watch, will cut off solar power to the 20-mc transmitter in a year.

Lyman-Alpha X-ray experiment, conducted by Herbert Friedman of NRL. It will measure ambient sun-produced Lyman-Alpha and soft X-rays, and is also expected to furnish significant data on increased activity due to solar flares on the sun's surface. Radiation intensity will be measured by a photosensitive ion chamber cylindrical in shape, ¾ in. in diam, and 1¼ in. long. The chamber, fitted with a window of lithium fluoride, is sensitive to radiation between the 1040 Å and 1340 Å. The only radiation of noticeable intensity in this band is the Lyman-Alpha line of atomic hydrogen at 1216 Å, which will be measured.

The X-ray instrument is similar in size and shape to the Lyman-Alpha detector. It is filled with argon gas, has a beryllium window, and is sensitive to radiation wavelengths from 15 to 3 Å. A photocell is included to determine the aspect of the satellite with respect to the sun.

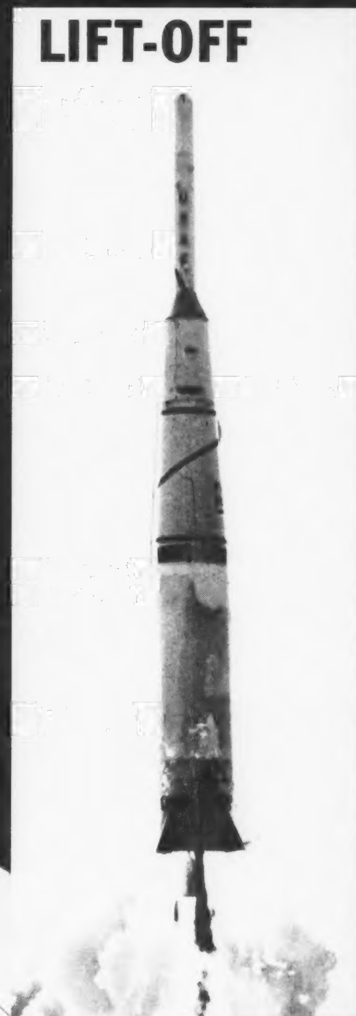
Heavy primary cosmic ray experiment, designed by the late Gerhart Groetzinger of Martin's subsidiary, the Research Institute for Advanced Studies (RIAS). It employs an ion chamber to count cosmic rays in three

FROM LAGRANGIAN TO LIFT-OFF

Sometimes forgotten during the thundering ascent of a space probe rocket are months of meticulous analysis, engineering and planning. The staff of Space Technology Laboratories is now engaged in a broad program of space research for the Air Force, the National Aeronautics and Space Administration and the Advanced Research Projects Agency under the direction of the Air Force Ballistic Missile Division. For space probe projects STL provides the total concept approach, including preliminary analysis, sub-system development, design, fabrication, testing, launch operations and data evaluation. The total task requires subtle original analysis in many fields as well as sound technical management.

The STL technical staff brings to this space research the talents which have provided system engineering and technical direction since 1954 to the Air Force Ballistic Missile Program. Major missile systems currently in this program are Atlas, Titan, Thor and Minuteman.

The scope of STL's responsibilities offers creative engineers, physicists and mathematicians unusual opportunities to see their ideas tested in working hardware. Inquiries are invited regarding staff openings in the areas of Advanced Systems Analysis, Rocket Propulsion, Space Flight Mechanics, Dynamics, Structural Analysis, and Aerodynamics.



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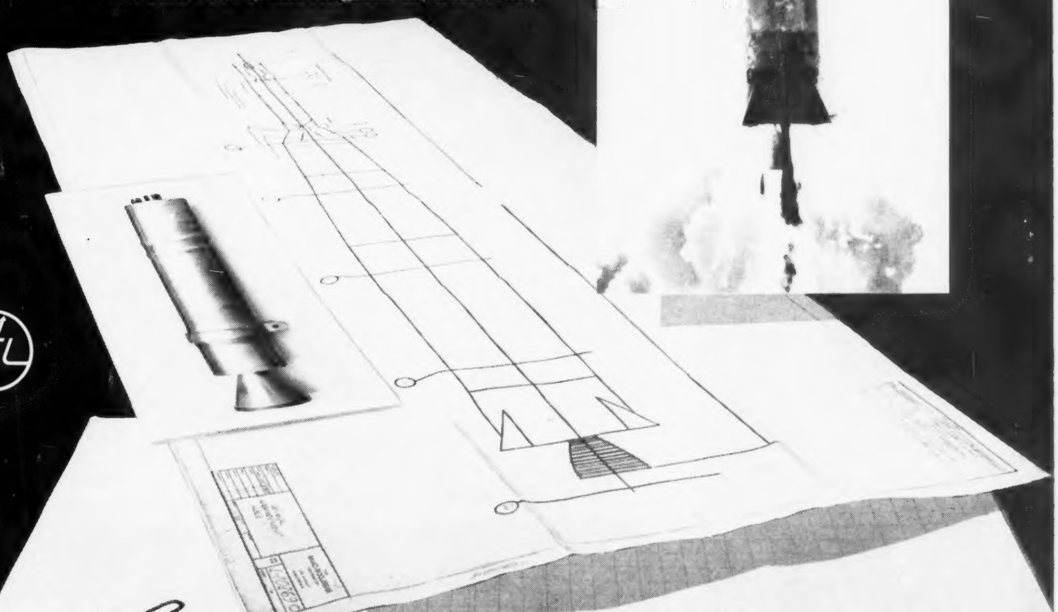
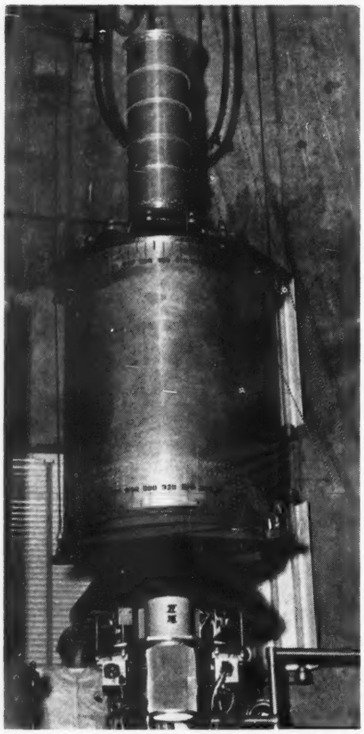
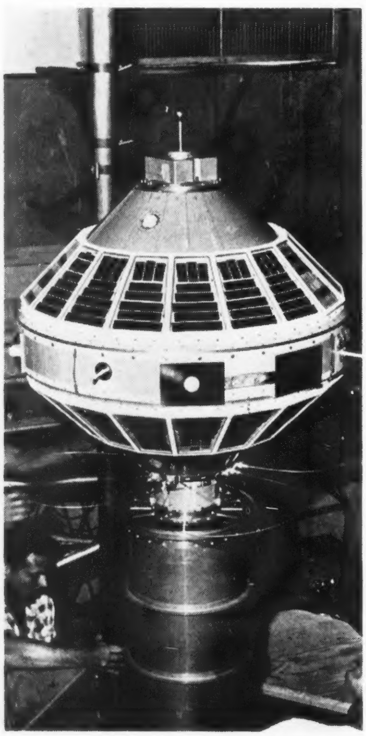


$$\mathcal{L} = \frac{m}{2}\left(\dot{r}^2 + r^2\dot{\theta}^2 + r^2\sin^2\theta\,\dot{\phi}^2\right) + \frac{GMm}{r}$$



Top, engineers prepare to align and balance JPL's three-stage cluster of solid motors for the Juno II launching vehicle. Below, they adjust Explorer VII on the cluster in preparation for spin testing.



ranges, having limits determined by the atomic numbers of lithium, carbon, and fluorine (numbers 3, 6, and 9 respectively). A particle with a number equal to or greater than 3 will be counted in one channel, equal to or greater than 6 in another, and equal to or greater than 9 in the remaining channel. The detection principle is based on the fact that all primary particles to be encountered will be completely ionized nuclei having relativistic velocity (greater than 0.9 times the velocity of light). The ionization chamber consists of a cylinder, closed at both ends, with a metallic wire along the axis that is insulated from the rest of the cylinder. The voltage maintained between this wire and the wall of the chamber is such that the wire collects all the electrons produced whenever a charged particle passes through the argon gas. The total charge reaching the central wire is proportional to the total ionization generated by the particle, and hence measures the charge of the particle. Output of the scaler circuits are converted to DC voltages.

Micrometeorite experiment, based on NRL work and conducted by Herman E. LaGow of NASA. It will detect micrometeorite impacts in the order of 10-micron diam or larger with an evaporated-cadmium sulphide photocell covered with an optically opaque film. An impact will produce an opening, which will admit sunlight into the cell through a diffusion surface of frosted glass. This sunlight will cause a drop in the output resistance of the detector. The telemetering system is designed to report resistance variations between 100,000 and 500 ohms. The aspect indicator in Dr. Friedman's experiment will serve to orient the cell.

Cosmic ray experiment, conducted by James Van Allen of SUI, The cosmic ray count will be measured by two tubes. One, similar to that flown in Explorer IV, has no special shielding and will be scaled 2048 to 1 to map the radiation belt. The other, with a lead shield approximately 1 mm thick, will be scaled by 128 to 1 to give the cosmic ray count below the belt. The output of both scalers will key a 4-step subcarrier oscillator.

Exposed solar cell experiment, conducted by ABMA to determine the performance of an unprotected solar cell in space. When incident light illuminates the cell, it develops some 5 v across a resistor. Voltage variation with time will indicate erosion effects.

Temperature measurement experiment. The indirect data taken to date on our satellites do not adequately explain their temperature histories. In the Explorer VII experiment, temperatures (in addition to those which are part of the LaGow and Suomi experiments) will be measured in an isolated skin area, a solar-cell cluster, a battery pack, and one of the Van Allen tubes. These data will be telemetered with the Suomi data.

In planning and development of the satellite proper, Ernst Stuhlinger, director of ABMA's Research Project Laboratory, coordinated test objectives and Herman LaGow of NASA was project engineer for experiments. Members of ABMA's Guidance and Control Laboratory provided the satellite: Joseph Boehm was responsible for design, packaging, and environmental testing of the satellite; Otto Hoberg for developing telemetry and tracking components and associated electronics necessary to form the complete system; Hans Fichtner for wiring, solar-cell, and battery systems; Gerhard Heller (Dr. Stuhlinger's assistant) for temperature control; and Heinz Kampmeir for development coordination.

Forerunner Satellite

Explorer VII is the forerunner of really large and experimentally complex scientific satellites. It is expected to make a major contribution to synoptic meteorology, spurring work in that science, and to provide important radiation data to the Project Mercury program, particularly on biological hazards of primary cosmic rays.

Despite the apparent complexity of Explorer VII, much effort went into producing a basic experimental simplicity for the satellite, one that will give accurate and unbiased data. It is expected that data from Explorer VII will do much to clarify and confirm current notions of the space environment. ♦♦

Cryogenic Materials Data Handbook Growing

NBS's Cryogenic Engineering Laboratory, Boulder, Colo., has issued the second quarterly increment to the *Cryogenic Materials Data Handbook*, which it is preparing for the AF Ballistic Missile Division. R. M. McClintock of the Cryogenic Lab invites comments and suggestions within the scope of the contract and information suitable for inclusion in the handbook. Requests for copies of the partially completed handbook should be directed to the AF Ballistic Missile Div., Air Force Unit Post Office, Los Angeles 45, Calif., Attn: Col. John R. Browning, WDSOT. The handbook when completed will be made available by OTS, Dept. of Commerce.

Synthesis

(CONTINUED FROM PAGE 35)

watt-hour. ("Synthetic Formaldehyde from Carbon Monoxide and Hydrogen—Mechanism of the Sensitized Photochemical Reaction," by A. L. Marshall, *J. Phys. Chem.* vol. 30, 1926, pp. 1634–1640.)

As shown diagramatically on page 34, the system for production of formaldehyde from equimolar quantities of carbon dioxide and water is intended for rather small-scale processing. The scale is large enough, however, to permit processing of at least one man's daily output of respired gases. The weights indicated opposite each unit in the process include associated hardware and instrumentation. No allowance has been made for the weight of the low-pressure tank to house the formaldehyde fuel synthesized, since this weight—actually about 100 lb per man-year operation—would be largely compensated by the otherwise necessary increase in the weight of the main fuel tank. The capacities for throughput in the electrolysis, reduction-vessel, and photochemical synthesis units are sufficient at the weights estimated to handle the required respired gases produced by a five-man crew. The drying agent and carbon-dioxide absorber units would normally be about five times heavier for this capacity. On this basis, the 60-lb system geared to a one-man respiration cycle would weigh only 116 lb for a five-man respiration cycle, or roughly double that shown on the diagram on page 34.

Weight Saved

An over-all schematic representation of the entire food-to-fuel process for a one-man year operation is shown on page 35. The saving in weight effected as a result of fuel synthesis from food byproducts per year's time for a five-man respiration cycle is estimated to be 2145 lb, or roughly a ton. This value is obtained as follows:

1. The five-man supply of food (2765 lb) yields same weight of carbon monoxide and hydrogen after respiration and degradation.
2. The 120 lb of synthetic process equipment should suffice to process CO and H_2 to produce 2765 lb of formaldehyde.
3. 2265 lb of hydrazine would be required to produce the same total impulse as 2765 lb of formaldehyde.
4. 2145 lb is the difference in weight between hydrazine replaced and processing equipment required. The total impulse realized due to the fuel synthesized per year for the five-man respiration cycle would be 770,000 lb-sec.

These data support the feasibility of producing significant quantities of storable fuel from spent food byproducts, while at the same time taking care of man's water and oxygen requirements on a regenerative basis. In view of its mass conservation, the food-to-fuel synthesis system would be logical for extended space missions. A comprehensive systems engineering analysis must be made to predict the type of space mission in which elapsed time involved and isolation would necessitate a mass conservation scheme like the one we have described. Elementary considerations alone show that the fuel synthesis scheme becomes advantageous when the weight of the fuel synthesized exceeds the weight of the regeneration equipment. Since the fuel produced in two or three weeks of a five-man crew operation equals the weight of the regeneration equipment, this period can be considered the lower level for the advantageous employment of the synthetic system. ◆◆

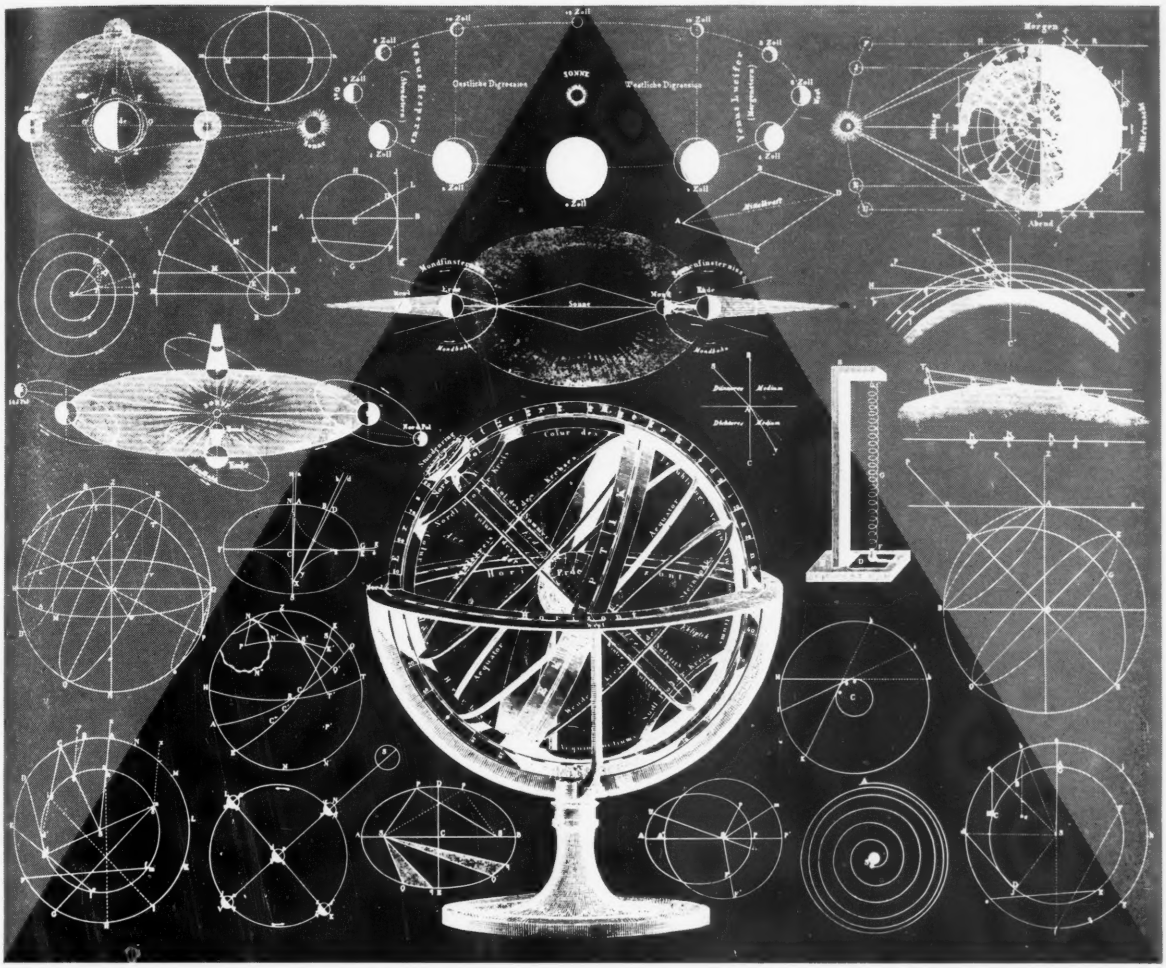
NASA Age One

(CONTINUED FROM PAGE 40)

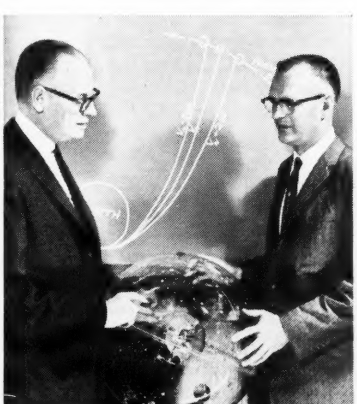
attenuation by a plasma, and generation of radio waves by colliding plasmas; and JPL's display of Vega, which included a model for explaining the "parking orbit" scheme for launching the vehicle's last stage. The Vega display included a model of the vehicle for a Mars mission, as shown on page 40, with instruments for measuring density and composition of solar corpuscular radiation, cosmic rays, and Mars' gravitational field and reflected spectral light, which would give clues to life on the planet.

By and large, the NASA Inspection showed little major vehicle development work other than for Vega and the Mercury capsule. Even more disappointing, there was little evidence of concerted efforts to explore and exploit nuclear rocketry. Concerning the importance of nuclear rocketry, see Frank Rom's concluding statements in his article, "Advanced Reactor Concepts for Nuclear Propulsion" and Robert Bussard's "Boundary Conditions for Nuclear Propulsion" in the October 1959 *Astronautics.*

Despite its tribute to NASA's organizational effort and a broad range of interesting laboratory work, the Inspection could leave you with the impression that a historical preoccupation with aerodynamics may be inhibiting progress on major space systems.—**J.N.**



Guided tour of the solar system



The new NASA Thor-boosted research rocket, DELTA, now being constructed by Douglas, will set up big signposts for further space explorations. Combining elements already proved in space projects with an advanced radio-inertial guidance system developed by the Bell Telephone Laboratories of Western Electric Company, DELTA will have the versatility and accuracy for a wide variety of satellite, lunar and solar missions. Douglas insistence on reliability will be riding with these 90 foot, three-stage rockets on every shoot. At Douglas we are seeking qualified engineers to join us on this and other equally stimulating projects. Some of our requirements are listed in our column on the facing page.

Maxwell Hunter, Asst. Chief Engineer—Space Systems, goes over a proposed lunar trajectory with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

People in the news

APPOINTMENTS

John M. Wild, wind tunnel pioneer, has joined General Dynamics' General Atomic Div. as director of Project Orion, and also as assistant director of the division's John Jay Hopkins Laboratory for Pure and Applied Science, San Diego. **Kenneth M. Smith,** former manager of long-range planning for Convair Div.—Pomona, has been appointed director of military relations for that division.

Aerojet-General has announced the appointment of **Norvin E. Erickson** as base manager for its operations at the AF Missile Test Center, Cape Canaveral. **Richard W. Powell** has been promoted from assistant manager to manager of the Avionics Div.

Maj. Gen. August Schomburg, deputy chief of Army Ordnance, has been named to succeed Maj. Gen. John B. Medaris, who is retiring as commanding general, Army Ordnance Missile Command, in January.

R. R. Morin has been made assistant chief engineer of Solid Propulsion Operations at Rocketdyne, and **O. I. Thorsen** succeeds Morin as program manager for the Thor IRBM engine development program.

Hans W. Weickardt has been appointed section chief of stress analysis in the R&D engineering division at Solar Aircraft.

Hughes Aircraft has named **C. Gordon Murphy** manager of the newly formed Advanced Program Development Operation within the Airborne Systems Group, while **Barney E. Turner** becomes manager of Air Defense Systems; **Norman E. Peterson,** manager, Tactical Systems; **Rex C. Mack,** manager, Space and Ballistic Missile Systems; **Paul S. Visher,** manager, Subsystems Dept.; **Malcolm D. Hudson,** manager, Microwave Products; and **Benjamin W. Davis,** manager, Nuclear Electronic Products.

Theodore Boxer has joined W. L. Maxson Corp. as director of the newly formed Ordnance Laboratory in the company's R&D Div. **Alexander N. Beichek** has been appointed assistant director of the Research Laboratory and **Charles J. Schmidt** has been named director of the R&D Div.'s Radiation Laboratory.

General Electric has announced the appointment of **P. R. Gehman** as manager, Missiles Applications Engineering, in the AF Requirements Operation of the Missile and Space Vehicle Dept.

George K. Hess Jr. joins Bendix Aviation as staff assistant to C. M. Edwards, associate director, technical, of the Research Laboratories Div.

George Morrison has been named first associate technical specialist in the Technical Service and Development Dept. of Dow Chemical.

American Bosch Arma has appointed **Stanley L. Haines** site manager of the Arma Div. Cape Canaveral Field Operation.

Samuel Lubkin, former manager, digital computer development, Curtiss-Wright Electronic Computer Div., has been appointed staff consultant to the Missile Systems Div. of Republic Aviation.

John Gronan has been appointed chief project engineer in the Nuclear Power Engineering Dept. of ALCO Products, Inc., while **Hans Schwarz,** senior project engineer, becomes manager of general engineering and development, R&D Dept.

Hugh L. Cox has joined Martin-Denver as lead engineer on advanced classified projects. **William P. Montague** has been named assistant director of electronic requirements at Martin—Baltimore, and **Arthur R. Christie** becomes manager of Martin's Washington, D.C., office.

Myrl E. Miller has been appointed manager of production engineering for explosives operation, Olin Mathieson Chemical Corp.

Alexander Black has been named vice-president and general manager, Missile Products Div.—West Coast, Fruehauf Trailer Co., while **Jack Keir** becomes director of military engineering.

Herbert I. Chambers has been made associate director of DataTape Div. of Consolidated Electrodynamics, with responsibility for the Engineering Dept., Special Projects Dept., and Magnetic Head Section. **Fred F. Grant** will manage the Engineering Dept. and **Edgar E. Hotchkin,** the Magnetic Head Section. **John G. Frayne** will head development engineering at Datalab.

D. S. Taylor and **C. L. Randolph** have been appointed president and vice-president, respectively, of U.S. Borax Research Corp., a subsidiary of United States Borax & Chemical Corp.

John L. Zambrow has been upped from manager, Metallurgy Dept., Sylvania-Corning Nuclear Corp., to director of engineering.

Thomas E. Holland, vice-president of Beckman & Whitley, has been made director of the recently formed R&D Div.

Louis P. Clark has been appointed manager of the Florida Div. of Radiation, Inc.

Donald S. Arnold has been named manager of research, American Potash & Chemical Corp.

Claire A. Stepnitz has been appointed supervisor of R&D, Bowman Instrument Corp., Fort Wayne, Ind.

Ralph E. Bucknam has been elected president of Gyra Electronics Corp., LaGrange Park, Ill., and also will serve as chief engineer responsible for development and manufacturing activities.

Electronic Specialty Co. has promoted **Benjamin H. Ciscel** from executive vice-president and director to senior vice-president and director. **Rollin M. Russell** succeeds Ciscel as vice-president and director.

Eugene T. Fleischauer has joined the engineering staff of Poly-Scientific Corp., Blacksburg, Va., as senior mechanical engineer.

The Landsverk Electrometer Co., Glendale, Calif., has appointed **Charles**

Erickson

Cox

Frayne

Clark

D. Gould chief engineer responsible for the engineering program of the Miller Metal Products Div., the Contract Div., and standard products in the company's Commercial Div.

Walter Ware Slocum has been appointed president of International Resistance Co., succeeding **Charles Weyl,** who has become chairman of the board.

Quentin G. Turner, assistant general manager, will also manage Motorola's development and production aspects of the M&TC Major Weapons System for North American's B-70. **Nicolas G. Sakiotis** has been appointed project leader in the Microwave Applications Laboratory, Solid State Electronics Dept.

Gen. H. Franklin Gregory has been appointed to the board of directors of Midwestern Instruments, Inc.

Rear Adm. R. H. Lambert (USN-Ret) has been named to head the newly formed Technical Council of the Society for Nondestructive Testing.

Kenneth G. Picha has been appointed program director for engineering sciences in the Mathematical, Physical, and Engineering Sciences Div. of NSF.

Bruce L. Wilson has been appointed chief of the National Bureau of Standards' Mechanics Div.; **Karl G. Kessler** has been appointed chief of the Bureau's Spectroscopy Section.

Robert E. Hollingsworth has been promoted to deputy general manager of the U.S. Atomic Energy Commission.

Marvin Lee has been elected president of Burndy Corp., succeeding **Bern Dibner,** who has been made chairman of the board of directors.

Allen B. Du Mont Laboratories, Inc., has announced the promotion of **Joseph Burns,** manager of cathode-ray tube design, to manager of its cathode-ray tube engineering laboratory.

William H. Thomas has been appointed Washington representative of Air Products, Inc.

Harold Vagtborg has been elected executive chairman of the development council and **Martin Goland,** president, of Southwest Research Institute.

Leonard Pode has joined General Controls Co. as chief engineer of the Electronic Systems Div.

Robert E. Talmo has joined the senior technical staff of Electro-Optical Systems, Inc., as head of the newly formed Transducer Laboratory, Solid State Div.

David A. Lupfer has been appointed general manager of the Materials and Ceramics Div. of Gulton Industries, Inc., while **Robert Day** has been made general manager of the Instrumentation Div. **Robert C. Shair** becomes director of research, Alkaline Battery Div.; and **Harlan P. Tripp,** manager, Ceramics Coating Dept.

Robert T. Blakely has been named chief engineer of product planning at Remington Rand Univac Div., Sperry Rand Corp., while **James D. Redding** becomes director of military applications with headquarters in Washington, D.C.

Robert M. Jackson has joined Garret Corp. as assistant to the vice-president in charge of sales, serving as consultant in the field of electronic and electromechanical systems.

William Perzley becomes director of engineering at Consolidated Avionics Corp., a subsidiary of Consolidated Diesel Electric Corp.

Designers for Industry, Inc., Cleveland R&D firm, has announced the appointment of **Waldemar Ayres** as director of technical surveys.

Schaevitz Engineering, Pennsauken, N. J., has established a new management group with **Soloman Hudes** as executive vice-president and **Morris Deitch** as production manager.

Richard C. Luiken has been named production manager of the Electron Tube Dept. of CBS Laboratories.

John C. Powers Jr. has joined the research laboratory staff at Metal Hydrides, Inc.

Epsco, Inc., has named **Rear Adm. Roy H. Callahan** (USN-Ret.) vice-president, administrative manager, to coordinate the Bosten Div. and **Philip Hood,** manager of production. At Epsco-Worcester, **Werner Fleig** becomes chief engineer; **Philip Amlinger,** chief electronic engineer. At Epsco-West, **Howard Carter Sr., Russel Quackenbush Jr.,** and **Winston Walker Sr.,** become project managers; **James Doyle,** senior engineer; and **Harry Levin,** quality control manager. At Epsco Systems Div., **Hammond Ladd** has been made product manager.

von Karman Gas Dynamics Facility Dedicated

In honor of Dr. Theodore von Karman, the Gas Dynamics Facility at ARDC's Arnold Engineering Development Center has been dedicated as the von Karman Gas Dynamics Facility. Present at the ceremony were, left to right, Dr. von Karman; Lt. Gen. Bernard A. Schriever, ARDC commander; Hugh Dryden, NASA deputy administrator; J. V. Charyk, assistant secretary of the Air Force for R&D; and Maj. Gen. Troup Miller Jr., AEDC commander, and many others. The Center was born out of recommendations Dr. von Karman had made in 1945 to the late Gen. H. H. Arnold, then commander of the U.S. Air Forces.

HONORS

Gen. Donald L. Putt, (AF-Ret.) president of United Research Corp. of Menlo Park, has been elected 1960 president of the Institute of the Aeronautical Sciences.

The Legion of Merit has been presented to **Col. Lawrence D. Ely** of the AF Ballistic Missile Div., a principal figure in shaping the Air Force's current missile and space programs and in formulating the original Man-in-Space plan.

A $3500 Minneapolis-Honeywell fellowship in instrumentation has been awarded to **Robert Lungannani** of Hightstown, N.J., an engineering honors graduate of Princeton Univ. who will complete his doctoral thesis in the area of advanced process control systems, specializing in optimized nonlinear control.

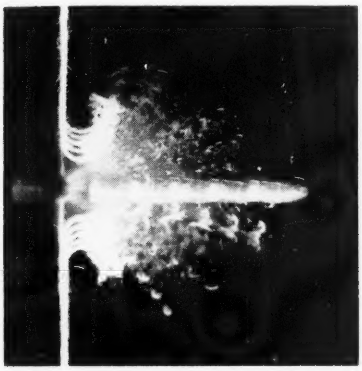
Solomon Lefschetz, professor emer-

itus of Princeton Univ. and director of a mechanical research center of Martin's RIAS Div., has received an honorary doctorate from the Sorbonne.

DEATHS

Thomas F. Rocco, base manager for Aerojet at the AF Missile Test Center, Fla., died suddenly on Sept. 20 at the age of 36. An ARS member, he joined Aerojet in 1953 and was appointed corporate manager of technical services in Florida in the fall of 1958.

Stopping a Bullet The Safe Way



Multiflash photo technique developed by Harold Edgerton of Boston catches a bullet breaking a string with six exposures on one piece of film. Each flash took a millionth of a second and the intervals a hundred thousandths of a second. White line shows bullet's rotation.

Data Solicited for New *American Men of Science*

The 10th Edition of *American Men of Science*, now in preparation, will be published in five parts on a four-year schedule, as follows:

- The physical and biological sciences, A–E
- The physical and biological sciences, F–K
- The physical and biological sciences, L–R
- The physical and biological sciences, S–Z
- The social and behavioral sciences, A–Z

Scientists should contact Jaques Cattell, Editor, AMS, Arizona State Univ., Annex 15, Tempe, Ariz., to corroborate listings, addresses, etc. The A–E volume is ready for the press, but an eligible scientist in this group can still be listed in the supplement.

Mercury Communications

(CONTINUED FROM PAGE 27)

sible. Vacuum tubes were used only in areas where the power level precluded the use of transistors or in the higher frequency ranges where transistors are not yet applicable.

Environmental Performance. The environmental performance of equipment is extremely important in the various phases of the capsule mission. Each phase has different requirements. Vibration, shock, and acoustic noise are of paramount importance in the launch phase. Temperature and pressure become important in the orbital and re-entry phases. Shock becomes a problem in the landing phase. The most serious factors are vibration and temperature. Foam encapsulation gives a rugged construction capable of withstanding vibrations during launching and re-entry. As for temperature, the most serious problem would occur during orbit in the event of capsule decompression. In this instance, heat sinks and watercooled plates would prevent excessive temperatures. All foam-encapsulated units have heat sinks connected to the heat-dissipating components within the unit. The heat sinks in turn join a structural member of the capsule to dissipate heat.

Naturally, a very thorough program of testing is planned in the Collins laboratories, at the McDonnell plant, and at the launch site. Testing will be done at the black box, or subsystem, level *and* at the complete system level both in the laboratory and in the field. In addition, exhaustive checkouts of equipment will be made during several unmanned flight-tests of the capsule.

Equipment Developed

Let's turn now to the equipment developed for the Mercury capsule. Under ground rules laid down by NASA and McDonnell, it was necessary to provide highly reliable equipment in a short time. By and large, existing techniques and off-the-shelf designs were used as far as possible. This resulted in black boxes rather than in integrated modules. However, some equipment had to be designed from scratch and very rapidly.

At present, Collins Radio is associated with nine other companies to provide the communications system for the Project Mercury capsule. Collins is designing and fabricating all voice-communications equipment, the Astronaut's control unit for communications, and the UHF rescue antenna. The antenna designs consist of a bicone antenna and separate microwave antennas for the radar beacons in the orbital phase and a rescue antenna and a balloon-supported wire for the re-entry and rescue phases. McDonnell is fabricating the bicone antenna, since it is an integral part of the capsule.

Subcontractors listed here have contributed to the remainder of the system, a discussion of which follows: Motorola, Inc.—command receivers; Texas Instruments, Inc.—telemetry transmitters; Cooper Development Corp.—Minitrack beacon; Avion Div. of ACF—microwave radar transponder, beacons; Simmonds Aero Accessories, Inc.—"Sarah" and "Sea Save" rescue beacons; Melpar, Inc.—microwave antennas; Microphase Corp.—multiplexer; General Mills, Inc.—balloon-supported antenna system; and Andrea Radio Corp.—audio control center.

HF Orbital and Rescue Voice Equipment. The orbital equipment consists of a separate transmitter-receiver with a common antenna, made possible by switched isolation networks between the antenna and re-

ceiver. The transmitter section consists of a crystal-controlled oscillator, driver, and two-tube power amplifier. A four-transistor modulator furnishes audio power for amplitude modulation. Speech clipping is incorporated in the audio circuits to increase the intelligence power. Provision is made for external-voice-operated (push-to-talk) operation. The receiver section is a TRF unit with a crystal-lattice filter between the antenna and the first RF amplifier stage, which determines the bandwidth. A transistor power converter supplies power for all high-voltage circuits. The high-frequency rescue equipment is like the orbital equipment, except that the final amplifier and modulator stages have been revised to reduce the power output of the carrier for better battery economy during the rescue phase.

UHF Orbital and Rescue Voice Equipment. This equipment consists of a separate transmitter and receiver using a common antenna, with switching by an antenna relay. The transmitter section, which uses subminiature tubes, consists of a crystal-controlled oscillator, a frequency tripler, and a power amplifier. A transistorized modulator provides amplitude modulation of the transmitter. Speech clipping is also incorporated in this unit. A transistorized power supply provides plate and filament voltage for the vacuum tubes. The receiver section is a completely transistorized, high-performance, single-conversion superheterodyne. The bandwidth of the receiver is determined by means of a crystal-lattice filter in the IF amplifier. The rescue UHF voice equipment is like the orbital equipment.

Command Receiver. This equipment consists of an FM superheterodyne receiver feeding a decoder which provides a number of command channels for capsule control functions. Each command channel is activated by a subcarrier tone transmitted on an FM signal. The receiver section uses 11 germanium mesa transistors in a double-conversion superheterodyne circuit. Following the discriminator, six silicon transistors amplify the subcarrier signal, which is decoded by sensitive filters in the supersonic range. Relays are driven from transistors to perform each command function. There is also provision for an emergency voice channel output.

Telemetry Transmitters. This equipment consists of two identical FM transmitters that have transistorized stages except for the driver and push-pull output amplifiers, which use ceramic tubes. Each transmitter has a linear FM oscillator and frequency-control circuits using unique crystal discriminators to stabilize the center frequency. Transistor frequency multipliers increase the oscillator frequency to the final carrier frequency. Transistorized power units supply filament and plate voltage for the output stages.

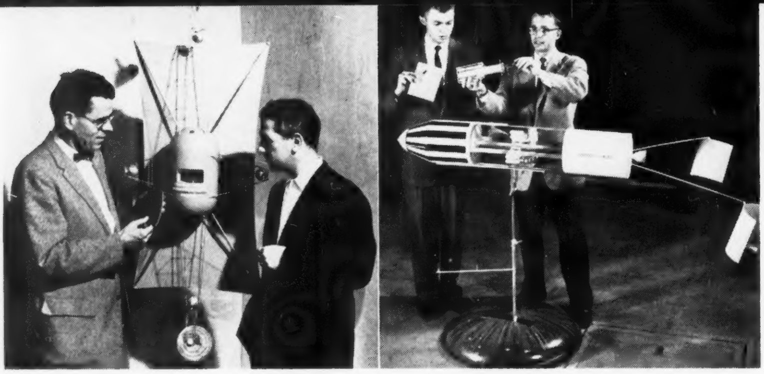
Orbital Tracking Beacon. This beacon, in conjunction with Minitrack or Microlock tracking ranges, gives capsule position data. The beacon is completely transistorized, and uses a crystal-controlled oscillator, frequency doubler, and push-pull output stage. An AM modulator is incorporated so that telemetry data can be transmitted via this circuit.

Radar Transponder Beacon. Two radar transponder beacons in separate but identical packages operate at different frequencies in the microwave range. Each beacon consists of a superheterodyne receiver, pulse modulator, power-output stage, and power supply operating from a 28-v DC source. Most of the beacon circuitry employs transistors, except for the local vacuum-tube oscillator and magnetron power-output stages. Provision is made for coding the beacons.

Rescue Beacons. These beacons, packaged as a single unit, contain a "Sea Save" HF-MCW transmitter and a UHF "Sarah" pulsed-pair transmitter. The circuitry is entirely transistorized except for the UHF "Sarah" beacon output tube. In addition to this beacon, provision is made for "Locar"-type homing by using the UHF rescue transmitter operated in the CW mode.

Audio Control Center. This completely transistorized unit centralizes all of the audio frequency and control circuitry for the entire communications system. Dual-channel amplifiers are provided for the microphone and head set. A voice-operated relay (VOX) operates the press-to-talk circuits of the voice-communications transmitters when the microphone output reaches a suitable output level. A command-receiver audioamplifier mixes and amplifies the voice input from the two command receivers. This amplifier has the necessary filtering to reject undesired command tones. Press-to-talk circuitry activates a recorder channel.

Control Unit. This unit, mounted within reach of the Astronaut, provides three controls for adjusting the level of the audio signal delivered to the Astronaut's head set. Audio controls are available for the high-frequency orbital and rescue voice equipment, UHF orbital and recovery equipment, and command-voice re-



Left, manned Counter-Moon model, shown being examined by its designers Richard D. White (right), and Walter Hiltner, Boeing's lunar-system manager. Right, Boeing model of 330,000-lb manned orbital research station design gets adjusted by engineers Gary Graham and Peter Downey. Both satellite vehicles could be launched by a propulsion system like the Saturn.

Boeing Design for Space Station and Counter-Moon

The pictured models show Boeing Aero-Space Div.'s design concepts for a manned orbital research station and a Counter-Moon satellite.

The orbital research station would weigh 330,000 lb and house 12 men in a near-earth orbit. It is designed to be sent up as a completely fabricated package, thus eliminating many problems involved in assembling station segments in space and matching orbits to do so. The whole station would spin to give an artificial gravity; sections of the station's shell, with solar cells on their inner surfaces, would fold out to collect solar power; and a parabolic nose-section shell would extend on an adjustable arm to serve as a communications antenna. A 60-in. telescope having its own communication, automatic-camera positioning, and propulsion systems would trail the orbiting station and be controlled from it.

The Counter-Moon, also a manned vehicle, would be placed in orbit around earth at the same altitude as the moon but directly opposite it on the other side of the earth. The Counter-Moon's instruments, used in conjunction with instruments on the moon and earth, would aid in determining accurately the position of solar-system and celestial bodies, serve as a navigational aid in space travel, make possible stereoscopic views of the sun, etc. Four ion accelerators would provide the power necessary for position control and maintenance of its orbit.

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ceiver. These controls, of the vertical thumbwheel type, drive audio attenuators through a spur gear train. A mechanical slip clutch can introduce a torque load to the control. A pushbutton permits emergency keying of the telemetry transmitters for CW telegraph communications. A toggle switch permits switching the UHF voice communications to the "Locar" mode of direction finding.

Antennas. There are four antennas in the capsule: The main antenna, the UHF descent-recovery antenna, the microwave antenna, and the balloon-supported wire for the HF rescue transmitters.

Separating two portions of the capsule, such that the junction makes a discone, forms the main antenna. This junction is fed by a coaxial cable at its center. The structure acts as a discone in the UHF range and as an asymmetrically fed dipole at HF and VHF frequencies. This allows simultaneous reception and/or transmission of all frequencies except the microwave beacon frequencies. The main antenna is used during launch, orbit, and part of re-entry.

The microwave-beacon antenna system—actually two antennas in one—consists of three dual-band radiators symmetrically arranged around the capsule, two sets of power dividers, and interconnecting coaxial cables. Each radiator has two cavity-mounted helix antennas that operate on widely separated microwave frequencies. The radiation pattern of this antenna is circularly polarized and has omnidirectional coverage around the axis of the capsule. The pattern coverage in the longitudinal plane is roughly a doughnut shape.

The UHF rescue antenna is a fan-shaped monopole located at the top of the capsule, and exposed by jettisoning the bicone antenna fairing during re-entry. Its primary function is to provide a radiator for UHF functions during parachute descent and sea rescue operations.

The high-frequency rescue antenna system consists of a monopole wire supported by an aerodynamically shaped balloon. It is capable of operation in winds up to 30 knots, with a maximum wire deflection of 30 deg from the vertical.

Multiplexers. There are two antenna multiplexers, one the main multiplexer and the other the high-frequency diplexer. The main multiplexer consists of a number of filters arranged so that seven frequencies can be coupled to the single bicone-antenna feed line. This unit provides from 40 to 60 db of isolation for each channel. The high-frequency diplexer consists of one high-pass and one low-pass filter, arranged so that two HF frequencies may be operated on the single feed line to the HF wire antenna.

The communications system for the Project Mercury capsule represents the first approach for a manned space vehicle. This approach has by intent been conservative, that is, based largely on existing techniques and off-the-shelf designs. It is the "black box" approach to a rather complex electronics system, and as a starting point it represents sound engineering that will do an adequate job in the Mercury mission.

Trend Away from Black Box

In communications systems for future space vehicles, the trend will probably be away from the black box and toward an integrated modular package. The complete system will be an aggregation of modules, some of which might be common throughout the functions to be provided. These modules should see more and more subminiaturization. Semiconductor devices will probably have advanced so that they may be used more widely. Eventually, microminiaturization may be applied to some of the components. However, microminiaturization will not be fully developed for some time, and it is anticipated that there will be several steps before arriving at true microminiaturization of communications systems for manned vehicles.

Further consideration will probably be given to multiplexing of circuits to eliminate a number of radio frequency channels and to reduce the volume of apparatus and antennas required. Also, considerable improvement in radiating devices for space vehicles will probably be achieved.

There is no doubt that the problem of space communications will become increasingly important as our efforts to explore space expand. The next decade should see considerable evolution from the present Mercury approach to the space communications system of the future. ♦♦

Missile market

BY JEROME M. PUSTILNIK, Financial Editor

HELPED by an 11 per cent gain for the month (compared with a 2.4 per cent increase in the Dow-Jones), the Missile Index closed at 966, retracing almost 40 per cent of the loss from its closing high of 1128 in May 1959.

The magnitude of this rise naturally leaves investors wondering if this is another dazzling ascent or is just a temporary rally, a brief interruption in the decline. Candidly, this column wonders, too.

Though increased spending may boost some programs, Saturn for example, defense budget ceilings still remain "sacred cows." The Administration seems disinclined toward actions that would place the United States into the space race with the Soviet Union. A shift in the Administration's thinking always is possible, of course, but such a change, if it is coming, is not yet evident, notwithstanding mounting pressure from the press. With these uncertainties, a cautious market policy should be followed.

Mirroring these uncertainties were the widely divergent price trends within the Missile Index during the past month. The aircrafts, with Martin one of the few exceptions dropped to new lows; whereas, propellant manufacturers and electronics issues enjoyed swift rises.

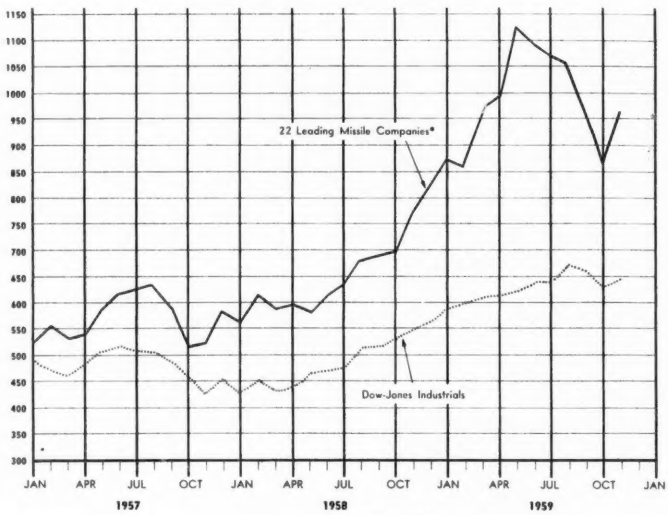
One of these electronics companies, General Precision Equipment, seems on the threshold of important earnings increases. A new but thoroughly experienced management is the reason.

Management has abandoned the former concept of GPE as a holding company, which only loosely coordinated the 12 operating subsidiaries. Instead, strict supervision is exercised, and emphasis rests on profit margins on sales and return on investment.

Almost 75 per cent of GPE's $200-million volume is with the military, in 33 different missile programs which provide guidance, control, fire control, ground support, and training equipment. The Kearfott subsidiary alone contributes components or subsystems to almost every significant missile program—gyro reference platform or guidance subsystems for the Bomarc, Subroc, and Talos; gyroscopes for the Atlas, Snark, Polaris, and nine other missiles; and precision servosystem components, accelerometers, and microwave equipment for a total of 20 missile programs.

Libráscope Div., has been selected by the Navy to develop most of the fire-control equipment for advanced surface and subsurface antisubmarine warfare programs.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	November 1959	October 1959	% Change	November 1958	% Change
Dow-Jones Industrials	647	632	+2.4	543	+19.0
Missile Index	966	870	11.0	775	+24.6

General Precision Laboratory, another subsidiary, continues to be a prime source of self-contained Doppler navigation equipment. It also manufactures high resolution closed-circuit TV systems.

In R&D, the General Precision group seems to demonstrate a very high level of scientific and engineering competence. Important work is underway, for example, on solid-state physics and microwave components at Kearfott; on infrared detection techniques at Librascope; and on studies of radar and nuclear gyroscopes at GPL. More than 4500 scientists, engineers, and technicians are employed in GPE's varied R&D programs.

Of the $50 million being spent in R&D this year, $4.5 million comes out of the company's own funds, with government sponsored projects constituting the balance. New military products (contributing to this year's sales) which have been developed include microwave and inertial guidance components, high precision 20-sec-accuracy synchros, subminiature rate gyros, an airborne minimal computer, and new devices to ignite solid or liquid fuels or to rupture missile structural members for stage separation.

As another example of GPE's technical excellence, in 1958 the Federal Aviation Agency awarded the company responsibility for over-all systems management of the experimental data processing and display system, Data Processing Central, that is the key project in developing the nation's new air traffic control system. Thirty-one other major companies competed for this contract. Prototype will be ready for testing early next year; and management believes production will be underway early in 1961. Other civil aviation projects undertaken include the jet and turboprop simulators manufactured by the Link subsidiary, and Radan Doppler navigation systems.

GPE is also among the leading manufacturers of automatic controls used in the steel, gas, oil, power, chemical, glass, and paper industries.

(CONTINUED ON PAGE 95)

Solid-Fuel Ramjet

(CONTINUED FROM PAGE 45)

vantage. The fuel does not have to be pumped, but neither can it be shut off and turned on again; nor can the fuel flow be adjusted on demand. However, for steady cruising flight, these disadvantages are not primary, although they do somewhat limit possible applications.

The SFRJ is not only reliable; it can also be designed to be extremely safe—safer in fact than the solid-propellant rocket that will have to boost the ramjet to operating speed. The SFRJ develops no static-thrust. Therefore, if ignited accidentally it may burn, but it will not move by itself. The fuel can be made to be completely safe. One successful experimental SFRJ fuel is composed of powdered magnesium and a small percentage of solid oxidizer (to sustain combustion, once started), which is compacted into a dense briquette under a pressure of 20 tons/sq in. This fuel briquette behaves very much like a billet of magnesium. It can be ignited—with difficulty. It cannot be detonated even by detonating a heavy explosive booster on top of it. No impact in laboratory explosive-testing machines sets it off. It can be machined in a lathe with simple precautions against igniting the chips and dust by friction. The photo on page 45 shows such fuel samples.

This magnesium fuel is physically strong. Because it incorporates so little oxidizer, its physical properties are essentially those of compacted magnesium powder alone. It can actually sustain accelerations as high as 2000 g without damage. It is relatively weak in tension and strong in compression.

The basic feasibility of the SFRJ has been adequately demonstrated both statically and in flight. Among those who have successfully flown the SFRJ are Experiment Inc., Continental Aviation and Engineering Corp., the former National Advisory Committee on Aeronautics, and the U.S. Naval Ordnance Test Station (NOTS). Flight performance was reasonably good for a propulsion system so lacking in experimental background.

SFRJ Design

The basic theoretical background for designing an SFRJ exists both in standard texts and in a large number of technical papers. Earlier issues of *Astronautics* have reviewed much pertinent material. Performance of various solid fuels can be calculated with confidence, and the calculations are well supported by experimental data. Many solid fuels, especially the light metals and the boron hydrides, promise high performance even in comparison with the best liquid fuels.

Although adequate theory for design exists both in texts and in journal articles, very little background in techniques and knowhow has been built up. In contrast to rocket technology, the difference is specially noticeable. A workable rocket *can* be designed right out of a handbook. Vast accumulations of personal experience in rocket design and knowhow are available. For example, rocket-propellant burning rates and compositions have been measured exhaustively.

This extensive background does not yet exist for the SFRJ. The burning-rate studies that have been made, for example, have been mostly spot checks or experiments made under a limited range of conditions.

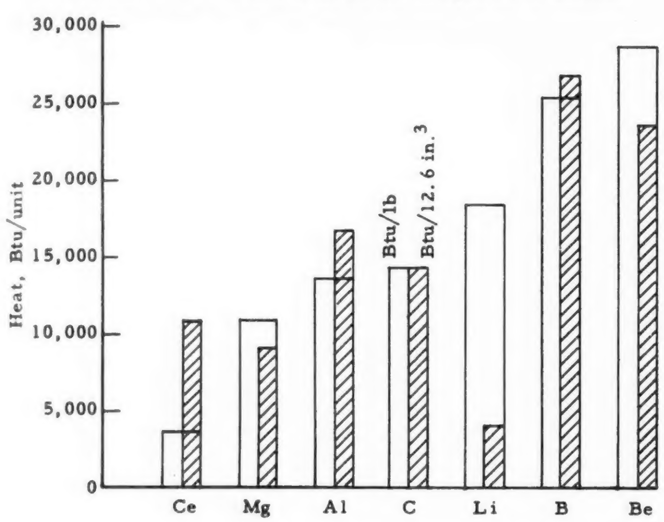
No adequate burning-rate theory exists for fuels used in the SFRJ. In fact, no adequate laboratory apparatus, equivalent to the Crawford bomb for measuring strand burning rates of solid propellants, exists. The situation is further complicated by the number of variables that must be examined in connection with the burning rate of solid fuels for ramjets. Not only do pressure and temperature effect the burning rate, but air velocity past the burning surface and the combustion volume also appear to effect it. No reliable techniques are currently available for examining these latter effects except by building and firing full-sized, or nearly full-sized, engines. This has seriously limited the extensiveness of the available burning-rate data.

During the past several years, NOTS has experimented with the SFRJ in order to accumulate some of this background knowledge. The purpose of the experimentation was not to develop a specific item of ordnance, but rather to examine the SFRJ in terms of its applicability to ordnance. Sufficient applied research has been done to allow the SFRJ to be used in the development of, say, a target drone. Understanding of burning-rate phenomena was achieved, but extensive data over a range of altitudes and Mach numbers remain to be obtained. Flight-tests have been conducted using only a few models flown under different conditions of altitude, acceleration, and so forth. The photo on page 45 shows a view of one of the experimental vehicles.

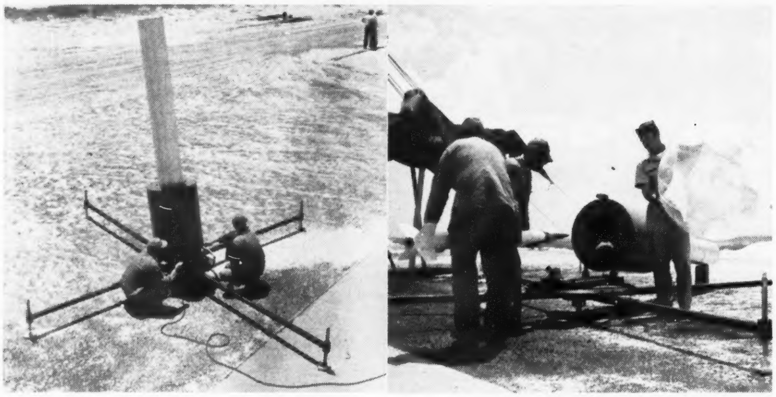
Combustion Efficiency

Considerable experimentation was done at NOTS with the split-flow combustor, in which burning takes place on the inner surface only. Air was bypassed around the outside of the charge at first only with the intention of cooling the tailpipe as previous experimenters had done. However, it was found that by using proper mixing devices to mix the bypassed air with the exhaust from the burning charge, greatly improved combustion efficiencies could be obtained. Also, charge breakup was eliminated by passing

Heat Output of Potential SFRJ Fuels Compared to Carbon



Robin–Rocket Balloon Instrument



ARDC's Robin meteorological rocket system, which can be handled by two men in the field, as indicated in the photos, was recently tested at Eglin AFB by AFCRC with the rocket shown, the 80-in. Arcas, produced by Atlantic Research. The rocket ejects the balloon (shown right) at the desired altitude (depending on rocket) from 100,000 to 250,000 ft, and ground radar tracking the reflecting surfaces of the sphere gives data for determining temperature, density, and wind direction and velocity of the atmosphere.

only about 10 per cent of the total air through the inside of the burning charge.

It was discovered that the burning rate of the fuel can be made basically dependent on the amount of oxidizer mixed with the fuel, rather than dependent solely on the air pressure. Thus the equivalence ratio can be made to change in the right direction to cause the ramjet to accelerate toward some pre-established velocity, although, as previously noted, accelerating flight does not give best fuel economy.

In static-tests carried out with the cooperation of U. S. Naval Missile Center, good fuel economies were obtained with the magnesium fuel. At low-equivalence ratios, fuel specific impulses as high as 1800 sec were obtained.

Aluminum-Based Fuels

Some tests also were carried out with fuels based on aluminum and on boron. Although the heats of combustion of aluminum and boron are considerably higher than that of magnesium, the actual combustion efficiencies were considerably lower. Any practical gain was questionable. Improvement in combustion kinetics may be obtainable by the use of additives, but this work remains for the future. The chart on page 92 shows relative heat content of several potential SFRJ fuels, compared to carbon.

When the requirements for ordnance are matched against the performance, safety, and reliability available from the SFRJ, it is evident that the SFRJ has considerable potential use. The present comparative lack of background and knowhow in designing the SFRJ is no insurmountable obstacle to its use. And in any case the technology is constantly improving.

Considering the characteristics of the SFRJ, it appears that there are several ordnance uses that it may fit very well. One fairly obvious use is for target drones for either surface or airborne weapons. The usually level flight, perhaps with simple maneuvers programed in and for ranges of from 10–100 miles at speeds up to Mach 4.5, fits the SFRJ perfectly. Its simplicity, with resulting low cost, further recommends it. A target drone can be visualized that is little more than a pipe lined with fuel. Such an engine could be manufactured in quantity for considerably less than $1000 per engine. The artist's sketch on page 44 depicts a cutaway view of a possible target drone of this type.

A second possible use for the SFRJ is in air-to-air missiles that require a range beyond that attainable with a rocket. The SFRJ can be pod-mounted on the airframe of the missile, or it can be designed integrally into the airframe. The latter case may require that the seeker system of the missile be able to look forward through the diffuser. Models for wind-tunnel tests have already been made of several combinations of seeker dome and ramjet diffuser. Workable designs have been found, although their recovery efficiencies were lower than have been desirable. These undoubtedly could be improved with further work.

A third use would be for extending the range of both air- and surface-launched missiles. Again, the ramjet can outperform the rocket except in very short and very long ranges. Although the ramjet can be designed to climb and accelerate, steady cruising flight yields higher fuel economy and shows more favorable comparisons. The SFRJ looks particularly good in the air-launched long-standoff missile system. In this application, it would be launched at a speed sufficiently high for ramjet operation, and thereby avoid the need for a large booster to get it up to operating speed. For 100-mile range, the ramjet is markedly smaller than the equivalent rocket. Ranges beyond 100 miles again favor the rocket because it can be launched on a ballistic trajectory and can travel outside the atmosphere.

At present, little work is being done in the United States on solid-fuel ramjets. Although several organizations have worked in the field at one time or another, there is at present no substantial research or development effort toward improving the performance or increasing the amount of design knowledge. Yet it is still possible to improve the performance of the SFRJ. The use of higher energy fuels, for example, might allow the range to be about doubled. To accomplish this, the combustion chemist must learn how to burn fuels like metallic boron. That difficulty seems surmountable.

Need for More Data

The problem of the present lack of extensive design data obtained over a wide range of conditions and with a variety of fuels will resolve itself as work is continued in the field.

Paradoxically, it appears that the SFRJ has not been used in ordnance *because* of its apparent simplicity. It is simple and therefore *difficult* to make work. A turbojet or rocket can use technical fixes to insure operation, but the simplicity of the SFRJ prohibits such fixes. The fundamental nature of the ramjet must be understood first. In the past, the apparent simplicity of the SFRJ has misled the eager experimenter to believe that the design must also be easy. No doubt the ensuing difficulties have to some extent discouraged the experimenter.

Yet, because the basic knowledge already exists, and only the handbook-type of design data is lacking, these difficulties are bound to be overcome. Rockets have already gone through a similar evolution. The future holds considerable promise that air-traversing weapons may yet be powered by the efficient, safe, and reliable solid-fuel ramjet. ◆◆

Missile Market

(CONTINUED FROM PAGE 90)

Other product lines for these industries include heat exchangers, and water distillation equipment. Although the motion picture field contributes considerably less business than it once did, GPE still is a prominent maker of 35-mm film projectors and sound reproducing equipment for theatres; and also produces outdoor theatre equipment, projectors, and cameras for TV.

Turning now to the earnings picture, several nonrecurring expenses plus the defense cutbacks of late 1957 and early 1958 diminished earnings to such an extent that, after preferred dividend requirements were met, GPE reported a loss. The most important factor was the loss GPE sustained on the manufacture of its new commercial jet simulators. The 1958 earnings were charged with the losses on simulators shipped that year, together with estimated losses on shipments to be made this year and in 1960.

A substantial improvement is underway this year, as these expenses will not recur. For the first 9 months, the company earned $1.85 a share, and management estimates full-year profits of $2.50 a share on $200 million of sales. For next year, GPE's first complete year under new management, earnings of more than $4.00 a share are projected.

Additional earnings will come, in time, from Royal Precision Corp., which GPE owns jointly with Royal McBee. Royal Precision has installed more than 225 of Librascope's LGP-30 computer, one of the more popular electronic digital computers on the market. But with more than 70 per cent of these units installed on a rental basis, Royal Precision's income has been limited almost entirely to rentals accrued during the year. Meantime, in order to finance this equipment on rental, to carry on development programs, and to train a qualified sales and service organization, heavy expenses have been absorbed and Royal Precision has not shown a profit. Rentals on these units, however, are accumulating, and they will produce favorable revenues in future years.

Listed on the New York Stock Exchange, General Precision Equipment has $47.9 million in debt, 97,078 shares of preferred stock, and three series of cumulative convertible preference stock ahead of its 1,125,810 shares of common. The Martin Company recently reported it has purchased more than 10 per cent of the outstanding common stock. ♦♦

Government contract awards

Nike-Zeus R&D Contract Awarded Western Electric

The Army awarded a $188,402,905 contract to Western Electric for research and development work on the Nike-Zeus anti-missile system.

$24 Million To Martin For Pershing Development

Martin's Orlando Div. has received a $24,000,000 Army contract for continuation of engineering services and other technical activities in the Pershing development program.

Norris-Thermador Awarded Polaris Production Contract

Norris-Thermador has received a production contract from Aerojet-General in excess of $1,500,000 for manufacture of first and second stage motor cases for the Navy Polaris.

Stellardyne Labs Wins AF Job

AF Ballistic Missile Div. has awarded Stellardyne Laboratories, Inc., a $200,000 project calling for testing and evaluation of pneumatic missile components.

New Contracts for Vitro Labs

Vitro Laboratories recently received Navy contracts totaling $6,500,000, including $3.25 million for a one-year extension of systems engineering work on Polaris, $2 million for design and development of a new torpedo weapon system, and $1.25 million on lesser projects.

Radar System

A Navy contract in excess of $200,000 for development, manufacture, and installation of a precision radar synchronization system linking all the tracking and surveillance radar facilities of the Pacific Missile Range has been awarded to Electronic Systems Development Corp., a subsidiary of Solar Aircraft.

High-Speed "Rod"

A one-year program for the study of a high-speed "Rod" switching-storage unit will be undertaken by National Cash Register under a $70,000 AFCRC contract. The Rod, developed by NCR, has switching speeds of 4 millimicrosec.

Metal-Fatigue Research

AFOSR has let a $38,574 contract to the Univ. of Illinois for continuation of basic research into internal friction (damping of elastic vibrations) in metals to provide a better understanding of metal fatigue.

Materials Contracts

Gulton Industries has received an AFCRC contract for development of a ceramic capacitor with an operating temperature of 250 C, and a Navy contract covering standard reference materials in the measurement and interpretation of thermal conductivity.

Aerojet Gets Eagle Job

Aerojet-General's Solid Rocket Plant has received an $8,000,000 subcontract from Grumman Aircraft to develop a high-performance rocket powerplant for the Navy's Eagle AA missile.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, Laurence G. Hanscom Field, Bedford, Mass.

R&D toward modification of operation so as to be fully mobile, $318,795, **Perkin-Elmer Corp.**, Norwalk, Conn.

Investigation of light emission characteristics during early stages of microwave plasma formation, $26,372, **Oregon State College**, Corvallis, Ore.

Recorder/reproducer for instrumentation, $44,890, **Ampex Corp.**, 392 Centre St., Newton, Mass.

Optical systems to be incorporated into satellite tracking cameras, $70,000, **Perkin-Elmer Corp.**, Main Ave., Norwalk, Conn.

Development and construction of a satellite orbit simulator and display prototype, $81,294, **James Pastoriza Associates**, 285 Columbus Ave., Boston, Mass.

Investigation of the interaction of high-powered R.F. energies and high density plasmas, $100,000, **MIT**, Cambridge, Mass.

Aerobee rockets, $488,051, **Aerojet-General**, Azusa, Calif.

Design and fabrication of a Doppler velocity indicator and accessories, $30,-

NASA CONTRACTS FOR AUGUST

Contractor	Obligation	Program
Aero Geodesic Astrophysical Corp.	$ 50,000	Radar tracking beacons and engineering services.
Aerolab Development Co.	$240,000	Sounding rockets for research.
	$ 70,000	Booster hardware for Mercury development.
AEC (Univ. of California)	$ 90,000	Studies of biological life-support systems in an interplanetary environment.
AEC	$ 80,000	Salton Sea drop tests for Project Mercury.
CalTech	$120,000	Research on rarefied-gas flows.
Case Institute of Technology	$180,000	Research on hybrid numerical circuitry.
T. R. Finn & Co.	$100,000	Develop techniques for fabrication of refractory coated metals.
JPL	$280,000	Purchase of equipment for use in tracking communications satellites.
	$ 70,000	Antenna conversion equipment.
Rennselaer Polytechnic Institute	$ 60,000	Continuation of research on dispersion-strengthened materials.
Univ. of Chicago	$ 70,000	Preparation of a basic lunar map.
Univ. of Colorado	$110,000	Instrumentation to measure ultraviolet radiation from high-altitude rockets and satellites.
Univ. of Michigan	$130,000	Investigate radar methods of exploring the moon and other planets.
Univ. of Rochester	$120,000	Research on solid-state photo detectors for orbiting astronomical observatories.
Yale Univ.	$150,000	Satellite and planetary motion studies.

000, **Rocky Mountain Instrument Co.,** 1912 Pearl St., Boulder, Colo.

Study to determine the feasibility of designing a new type antenna to be used with ionospheric sounding system on a KC-135 type aircraft, $39,266, **Boeing Airplane,** Transport Div., Benton, Wash.

AMC Aeronautical Systems Center, USAF, Wright-Patterson AFB, Ohio.

Falcon missile composite flight-test program, $2,820,000, **Hughes Aircraft,** Florence Ave. & Teale St., Culver City, Calif.

Arnold Engineering Development Center, Air Research & Development Command, USAF, Tullahoma, Tenn.

Frequency modulated pressure system, $69,350, **Wiancko Engineering Co.,** 255 N. Halstead, Pasadena, Calif.

Digital pressure measuring system, $691,753, **Consolidated Systems Corp.,** A Subsidiary of Consolidated Electrodynamics Corp., 1500 S. Shamrock, Monrovia, Calif.

Multichannel system for analog to digital conversion, $239,999, **Beckman Instruments, Inc.,** Beckman Systems Div., 825 N. Muller Ave., Anaheim, Calif.

On Location with a Missile

The first pictures of the earth from an altitude as high as 700 miles were taken August 24 from an Atlas-boosted GE re-entry vehicle (No. 422) incorporating a GE data-recovery capsule. This vehicle arced down the Atlantic Missile Range over a 5100-mile trajectory with an apex of about 800 miles. It was the first of the Atlas series of test vehicles to carry a data capsule, and the second to have three-axis control, which stabilizes the vehicle on the up-leg and rotates it into re-entry attitude after apex.

A 16-mm camera in the data-recovery capsule took movies between altitudes of about 200 and 700 miles on the ascent. One photo here shows a frame at the 700-mile altitude. The larger picture shows a mosaic of several hundred frames to give a panoramic view of the indicated portions of the earth. This view has yielded meteorologists valuable weather information.

The re-entry vehicle control system employs two infrared horizon sensors, directed 90 deg apart, for horizontal-axis and pitch stabilization. It uses a single-axis magnetometer to stabilize yaw. These detectors produce control by feeding data to a computer whose output meters six control jets.

The GE re-entry capsule tape-records telemetry data on flight control. This data can be correlated with the movie record to derive mosaics like the one pictured.

Above, a single frame from an altitude of approximately 700 miles shows Africa at lower left and South America at center horizon. The picture spans a linear distance of about 2000 miles. Below, this view of the earth, a mosaic of frames taken by a GE data capsule on the up-leg of an Atlas flight reaching an apex of 800 miles, reveals the global sweep of weather.

Director of Procurement, AF Office of Scientific Research, Washington 25, D.C.

Continuation of research on thermal effects in aircraft structures, $18,500, **Leland Stanford Jr. Univ.,** Stanford, Calif.

Continuation of research on development of arc-heated low density wind tunnel, $25,000, **Univ. of California,** Berkeley 4, Calif.

Continuation of research on nuclear emulsion studies of the properties of hyperfragments, $80,458, **Univ. of Chicago,** Chicago 37, Ill.

Acceleration and continuation of far infrared research, $35,250, **Johns Hopkins Univ.,** 34th and Charles Sts., Baltimore 18, Md.

Research on high-speed gas dynamics, $149,446, **Princeton Univ.,** Princeton, N.J.

HQ, Air Research and Development Command, USAF, Holloman AFB, N.M.

Magnetic-tape recorder instrumentation for telemetry system, to be used in support of project WS-133A, $25,795, **Ampex Corp.,** Instrumentation Div., 8467 Beverly Blvd., Los Angeles 48, Calif. Negotiated procurement.

Calibrator and transmitter to be used in support of project WS-133A, $27,000, **Electro-Mechanical Research, Inc.,** P.O. Box 3041, Sarasota, Fla.

ARMY

Army Medical Research and Development Command, Washington, D.C.

Research on synthesis of potential antiradiation drugs, $36,355, **Stanford Research Institute,** Menlo Park, Calif.

Research on synthesis of potential antiradiation drugs, $63,188, **Arthur D. Little, Inc.,** Cambridge, Mass.

Army Ordnance Dist., Bingham, 2120 Seventh Ave., N. Birmingham 3, Ala.

Engineering and design services and ground support equipment for Saturn missile, $240,000, **Hayes Aircraft Corp.,** P.O. Box 2287, Birmingham, Ala.

FY 60 LaCrosse R&D program definitive contract, $998,800, **Martin Co.,** Sand Lake Road, Orlando, Fla.

Facilities for production of LaCrosse and Pershing weapon systems, supplement, $100,055, **Martin Co.,** P.O. Box 5837, Orlando, Fla.

Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Experimental study of propulsion system, $84,979, **Plasmadyne Corp.,** 3839 S. Main St., Santa Ana, Calif.

Activation and operation of launching equipment, $92,682, **Aerojet-General,** Azusa, Calif.

Mechanistic studies of igniters, $39,924, **Redel, Inc.,** 220 N. Atchison St., Anaheim, Calif.

Weapon system study, $251,808, **Harvey Aluminum, Inc.,** 19200 South Western Ave., Torrance, Calif.

Rocket engines, $304,000, **North American Aviation,** 6633 Canoga Ave., Canoga Park, Calif.

Warhead, $130,357, **Aerojet-General,** 5632 N. Irwindale Ave., Azusa, Calif.

Army Ordnance Dist., St. Louis, 4300 Goodfellow Blvd., St. Louis, Mo.

R&D of booster metal parts for Missile "A" rocket, $59,048, **Emerson Electric Mfg. Co.**, 8100 Florissant Ave., St. Louis, Mo.

Develop and apply a practical procedure for cleaning Saturn missile parts, components, and/or systems, $75,000, **Dow Chemical Co.**, P.O. Box 536, Tulsa, Okla.

Army Signal Supply Agency, 225 S. Eighteenth St., Philadelphia 3, Pa.

Low-speed drone system, $37,964, **Radiophone**, A Div. of Northrop Corp., Van Nuys, Calif.

R&D work for 12 months to conduct investigation leading to development of high-efficiency silicon solar cells, $96,977, **Transitron Electronic Corp.**, Wakefield, Mass.

Research work for an additional 3 months to conduct study and experimentation in the guided missile and range instrumentation field in the telemetry area, $66,459, **Aeronutronic Systems, Inc.**, Glendale, Calif.

Cincinnati Ordnance Dist., 230 E. Ninth St., Cincinnati 2, Ohio.

Cesium ion rocket performance evaluation, $45,082, **General Electric**, Cincinnati 15, Ohio.

N.Y. Ordnance Dist., 770 Broadway, N.Y. 3, N.Y.

Study, design, and fabrication of nine prototype accelerometer monitors and microminiaturized 3-speed synchro assemblies utilizing size 8 synchros for ground equipment for the Jupiter guidance system, $32,747, **Bulova Research & Development Laboratories, Inc.**, 62-10 Woodside Ave., Woodside 77, N.Y.

Research and development of the Nike-Zeus (Nike II) guided missile system, $188,402,905, **Western Electric Co., Inc.**, 120 Broadway, N.Y. 5, N.Y.

NAVY

Bureau of Aeronautics, Washington 25, D.C.

Investigation to develop ductile beryllium composites and determine the mechanical properties of materials produced, $30,000, **Armour Research Foundation**, Illinois Institute of Technology, Chicago 16, Ill.

Conduct investigation and perform tests to develop high-temperature resistant resins based on complex information with organotitanates, $28,500, **New York Univ.** (College of Engineering), N.Y. 53, N.Y.

Services and materials to conduct a product improvement program on the Model J34 turbojet engine, $4,800,000, **Westinghouse Electric Corp.**, Washington, D.C.

Materials and services for investigation of hot salt corrosion of titanium alloys at elevated temperatures, $77,900 **Crucible Steel Co. of America**, Midland, Pa.

Office of Naval Research, Washington 25, D.C.

Research to insure maximum effectiveness of a weapon system, $35,285, **American Institute for Research, Inc.**, Pittsburgh, Pa.

JPL'S Wind Tunnel

(CONTINUED FROM PAGE 46)

the walls of the nozzle. A system of 16 hydraulic jacks contour top and bottom plates to profiles within 0.0002 in. of theoretical.

This design approach derives from JPL's pioneering work on its two supersonic tunnels, and the hypersonic tunnel shows similarities with the supersonic ones. The hypersonic tunnel, however, involves much more stringent pressure, temperature, and tolerance demands. In particular, the air-flow must be heated before entering the nozzle to prevent formation of liquid air during expansion (see diagram page 46). Air at 1350 F prevents liquefaction at Mach 9. This introduces formidable local heating in the air-supply section, nozzle throat, and test-section. The supply section is water-cooled on the exterior and insulated on the interior, with a thin metal fairing channeling hot air through it. The rest of the tunnel is cooled with a system of internal water jackets placed as close to the air-wetted surface as possible, rather than on the outside. A high-pressure, closed-loop system employing deionized water cools the critical nozzle

Above, the throat, formed by beryllium-copper blocks, closes to a rectangular slit 17 in. wide and 0.045 in. high for operation at Mach 9.

throat. Other details can be inferred from the diagram on page 46.

Instrumentation for the tunnel is what might be expected, with the one twist that the Schlieren system is completely enclosed in a 40-ft pressure vessel that can be evacuated to high partial vacuum.

The prime contractor for the new hypersonic tunnel, Westinghouse Corp., built the supply section, nozzle, test section, and diffuser; Ingersoll-Rand built the compressors; Kewanee Ross Corp. supplied the aftercooler, and Foster Wheeler the heater. JPL's Roger M. Barnett heads tunnel operations.

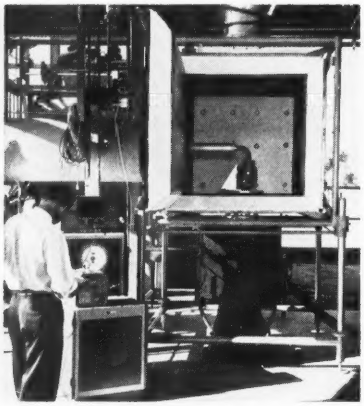
The new tunnel's services will be allocated equally among NASA research and Army and Air Force weapon-development testing, in projects too numerous to list.

Altogether, the new hypersonic wind tunnel promises to keep JPL prominent in aerodynamics, and stands as a tribute to the foresight and institutional strength of GALCIT and its pioneers.—J.N.

New equipment and processes

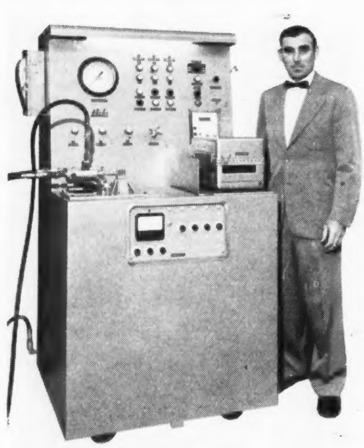
Gaseous Oxygen Valves Tested in Operation

Gaseous oxygen valves, such as the relief valve for the X-15's lox system, can now be tested under combined conditions of vibration and gas flow simulating actual operations. Whittaker Engineering Laboratories turned this trick by attaching a valve to the ullage chamber of their gaseous-oxygen facility and to an electrodynamic shaker in the special setup shown here. Sinusoidal vibration is supplied by a Ling Electronics vibration power generator (Model PP 40/40), which provides up to 5000 lb force over a range of 5 to 5000 cps. A cycling oscillator excites the valve through a full range of frequencies as the temperature of the test chamber drops.



Whittaker setup for testing gaseous oxygen valves under simulated operating conditions.

Tests Missile Stage-Release Mechanisms



This stand checks the operation of pressure-actuated release mechanisms for missile stage separation. It has microsecond settings for response; pressure tolerance of less than 1 per cent; no flexible tubing to distort the pressure system; either manual or automatic operation; colored-light pressure monitoring system; and millisecond readouts of action. The Hicks Corp., Hyde Park, Mass.

Solar-Cell Coating: A composition of magnesium fluoride and silicon monoxide coated in a 2.5-micron-thick layer on silicon solar cells re-radiates long-wavelength IR, and thus helps keep cell temperature down and efficiency high. Bausch and Lomb Optical Co., Rochester 2, N.Y.

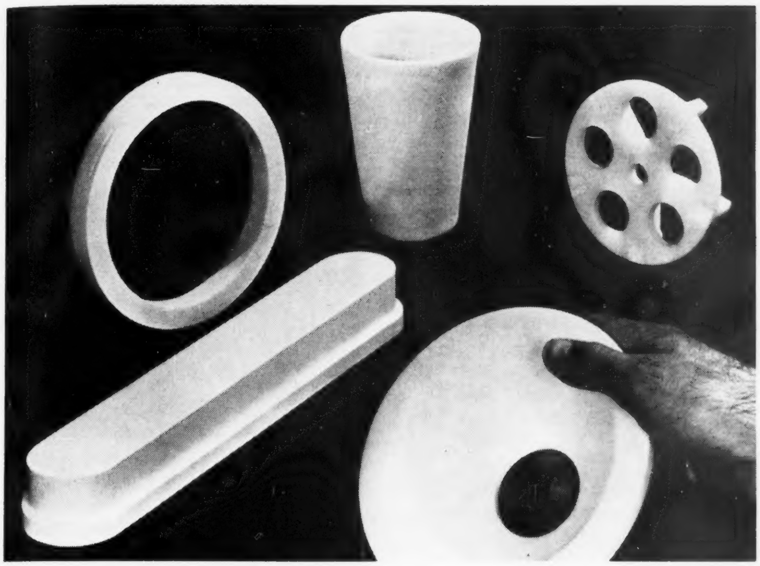
Small Transistorized Computer: Performing more than 100,000 calcula-

tions per minute, this desk computer, designed for analyzing fairly large scale operations, operates on a stored program with paper tape and electric typewriter inputs and outputs. Two advanced programming systems and a comprehensive library of routines simplify its programming. IBM Data Processing Div., 112 East Post Road, White Plains, N.Y.

Teaching Machine: An automatic reader with access to any of 10,000 items stored on microfilm simply by

pressing a button, this machine presents materials to a student at his own pace and tests his responses for accuracy and depth. A recorder gives the answer record and its time sequence. U.S. Industries Inc., Western Design Div.

Microdosimeter System for X-Ray and Gamma Radiation: The system is composed of the detector, a small cylinder of silver-activated phosphate glass, and a new reader. The reader measures change in fluorescense that takes place in the cylinder as a result of exposure to high-energy radiation. The system measures radiation accurately in the 10 to 10,000 rod range. Individual as well as cumulative dose readings may be taken over extended periods of time. Bausch & Lomb Optical Co., Rochester, N.Y.



New Silica Forming Process

A technique for producing high-purity fused silica in shapes and sizes never before possible has been developed by Corning Glass. Through an adaptation of Corning's Multiform process, fused silica can now be formed into cylinders, domes, rods, and slabs, making it possible to exploit the unique thermal and electrical properties of silica glass in many flight-vehicle applications.

Most properties of Multiform fused silica are said to vary only slightly from those of the parent glass. The material can withstand long-term use at temperatures over 1700 F and intermittent use to 2250 F. The softening point is 2880 F. Coefficient of thermal expansion is 3×10^{-7} per deg F, and the material displays a very stable dielectric constant and low loss tangent over a broad temperature range. It can be machined to tolerances of ±0.001 in., and has a density of 1.9–2 g per cc and a porosity of 9–13.6 per cent.

Samples of Multiform fused silica are available from the New Products Div. of Corning Glass Works, Corning, N.Y.

Permanent Magnet Focusing Arrays: Available are a wide variety of arrays designed and manufactured to traveling wave tube requirements. A typical array utilizes PM-3 ferrite material together with specially designed pole pieces to give small, light units. The array has a peak magnetic field strength of 1200 gauss, and weighs 3.2 lb. Kearfott Co., 1500 Main Ave., Clifton, N.J.

Storage Tube: A barrier grid tube capable of resolving 800 to 1200 TV lines at 75 per cent contrast has been developed for the U.S. Army Signal Corps. The tube utilizes a single electrostatically focused and deflected beam for both "writing" and "reading" information on a spherically curved target. International Telephone and Telegraph Corp., 67 Broad St., New York 4, N.Y.

Magnetless Ferrites: Less than one-third the size and weight of older ferrite components which require heavy external magnets, a new "magnetless" ferrite isolator has a magnetic field unit fitted inside the coaxial envelope. The field unit replaces external magnets and supplies the force necessary to control the transmission characteristics of the ferrite metal. Sperry Microwave Electronics Co., Div. of Sperry Rand Corp., Clearwater, Fla.

Miniature Ceramic Ladder Filters: Low-impedance filters featuring increased selectivity and stability in a 6-db bandwidth range of 4 to 50 kc occupy a space less than 1 cu. in. The units replace conventional filters containing as many as 30 elements, and having a volume of 64 cu. in. No magnetic shielding is required, and

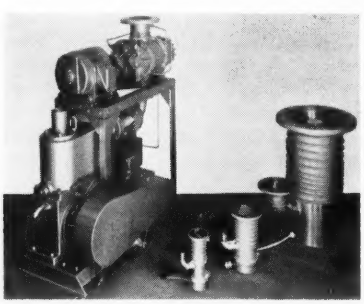
components can be buttmounted next to other circuit elements without electrical interference. Clevite Electronic Components, Div. of Clevite Corp., 3311 Perkins Ave., Cleveland 14, Ohio.

Nickel in Cathode Material: RCA will use N132 nickel compositions in the production of cathodes for more than 50 types of electron tubes. Production by a special vacuum-melting process reduces the maximum level of contaminants, such as cobalt, copper, iron, and sulphur. The proportion of carbon, magnesium, manganese, silicon, and titanium is strictly controlled. Radio Corp of America, 30 Rockefeller Plaza, New York 20, N.Y.

Thermal-Resistant Magnesium Alloy: Consisting of magnesium, didymium, and zirconium, EK31XA has double the strength of any known light metal at 500 F. The material has the following mechanical properties: Ultimate tensile strength, up to 26,000 psi; yield strength, 16,000 to 19,000 psi. Quantity production of castings in the new alloy has started. Cast Alloy Co., Inc., W. Central St., Natick, Mass.

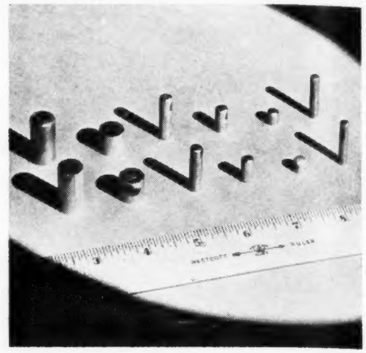
Low-Cobalt Stainless Steels: Two new nuclear stainless steels are now commercially available. One is a very low cobalt stainless used for containers and internal structural members in atomic reactors. The other is a high-boron stainless for reactor shielding and control rods. Universal-Cyclops Steel Corp., 1700 Arrott Bldg., Pittsburgh 22, Pa.

Oil Diffusion Pumps: In a series of compact pumps, a 300 cfm mechanical booster combines a Roots-type, positive-displacement blower and rotary gas ballast oilsealed unit to provide high-pumping speed. Pressure range is from 1 mm to 0.5 micron Hg.



Model H1OSP has a rated pumping speed of 2600 liters per sec, and an ultimate pumping pressure of 5×10^{-7} mm Hg. Model H2SP has a speed of 80 liters per sec. NRC Equipment Corp., 160 Charlemont St., Newton 60, Mass.

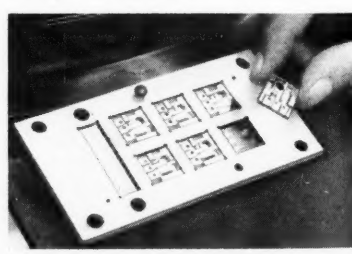
Thermoelectric Elements: Lead telluride thermoelectric elements are now available from 3M for experi-



mental and prototype engineering. Calculated thermal efficiency at matched-load conditions for the elements under a temperature differential of 1000 F is 7.85 per cent. They come in six standard sizes, with prefinished hot-junction surfaces and pretinned cold surfaces. The company offers services in applying the devices. Minnesota Mining and Manufacturing Corp., Dept. D9-401, 900 Bush Ave, St. Paul 9, Minn.

Double Stub Tuner: Featuring subminiature size, an RF radial tuner for the 100 to 2000 mc range weighs 2 lb. The unit replaces and duplicates the performance of the usual "trombone" sliding stubs. Rotating tuning rings give calibration references from 0 to 25. Adjustment of 12.6 in. with 1.9 in. spacing is provided. Characteristic impedance, 50 ohms. Don-Lan Electronics, Inc., Santa Monica, Calif.

Micro-Circuit



Microminiaturization R&D at International Resistance Co. has made ordinary passive circuit elements practically weightless by giving them molecular dimensions. To produce the microcircuit, exceedingly thin films of component materials were deposited on a tiny substrate of glass smaller than a postage stamp. The photo shows partially completed microcircuits in a holding fixture used in manufacturing. The unit was specifically designed for American Bosch Arma's missile-borne computer program.

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SUBJECTS

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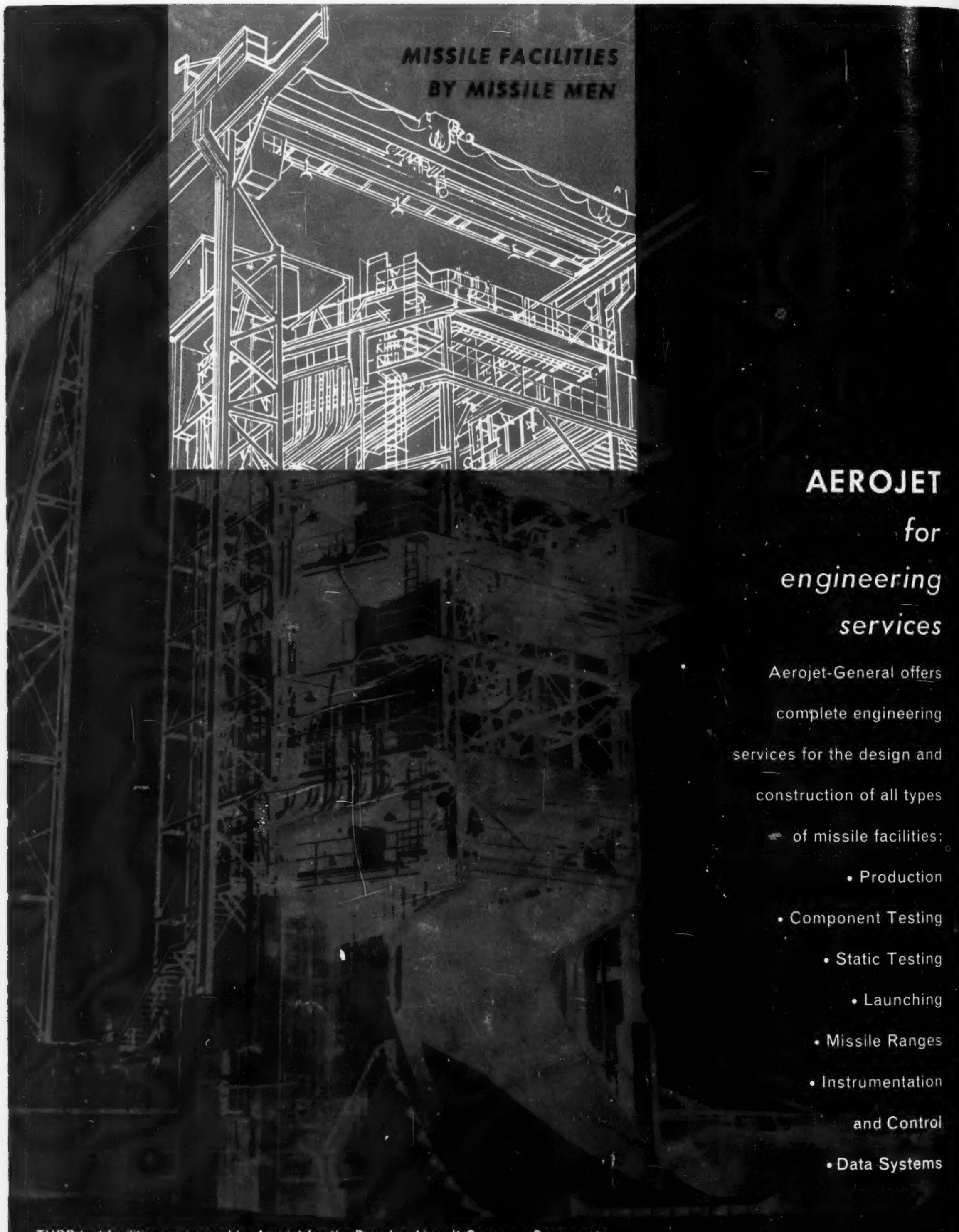

THOR test facilities engineered by Aerojet for the Douglas Aircraft Company, Sacramento